1946

From
J. R. Watson
to C. H. Willoughby
Univ of Florida

Hidden Hunger

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Dedicated to

RUSSELL HENRY CHITTENDEN

1856–1943

Dean of American Pioneers in

NUTRITION

Preface

In the quarter-century between the world wars the science of nutrition came of age. In the latest upheaval its knowledge and resources played major roles on the firing line and on the production line. During the war, applied nutrition has strengthened our armed forces, increased production, speeded the recovery of our wounded and protected the the health of our children. In the tomorrows, nutrition can be the greatest single factor in perpetuating the peace.

Nutriton is the key to attaining and sustaining the state which is aptly designated as buoyant health. Concomitant with this "physical fitness" comes mental health, with enthusiasm, exuberance and zest in life. Achievement is the sequel of health and happiness—of extending the life in the years as well as the years of life. Also, through nutrition humanity has the means to evolve populations of greater physical (and mental) capacities by constantly improving the bodies of the current generations. Whether the potentials of nutrition are fully employed will influence the course of civilization, for in this respect man's destiny can be self-determined.

In this volume we have tried to show how integration of the fundamental and applied sciences has occurred in the development of what McCollum, in 1918, termed *The Newer Knowledge of Nutrition*. Since World War I, both knowledge and application of the science of nutrition have steadily accelerated. With this development has come increased awareness of the necessity for approaches to nutrition problems from every one of their many aspects. Recognition of nutrition as the requisite to far more than satisfying hunger has focused worldwide attention upon the problems of HIDDEN HUNGER.

We could not have accomplished a task of such magnitude in the midst of a full wartime schedule had it not been for the capable and efficient help of Ralph E. Sloan, Editor, and Frances Emmons, Secretary, of the Research Laboratory of the Children's Fund of Michigan.

Icie Macy-Hoobler
Harold H. Williams

Detroit, Michigan

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Chapter One

THE SCIENCE OF NUTRITION

Food and Civilization

Man's first need is food. In certain parts of the earth clothing is unnecessary and shelter need be only a roof over one's head, but the need for food must be met everywhere, every day, if health is to be maintained. The struggle of the human race to obtain food and provide a reserve to safeguard against famine is, if it could be written, largely one of man's rise from cave-life to modern society. It is evident that wars among early mankind revolved around the food supply. Food was wealth and therefore the main economic factor in the life of primitive times. But even as food was the basis of the simple economics of our savage ancestors, it is none the less basic in the complex of our modern civilization.

It is a tragic reflection on today's "enlightened" peoples that it took a global war to make us conscious of the importance of our food supply and the conservation of human life. Few of us realize what it is to go hungry. Our supposedly abundant food supply has lulled us into a false sense of security. We have thought that since food was available for us it was likewise available to our neighbors. Yes, we have heard of famine in China; and in India! We have seen breadlines in our own cities. But do we realize the implications, the potentialities that reside in such conditions? Apparently not, until it is too late. One who has seen men in all stages of starvation has said that if a man misses his meals one day, he will lie; if he misses his meals two days, he will steal; if he misses his meals three days, he will kill. Far-fetched? Perhaps, yet one of our war slogans is "Food Will Win the War and Write the Peace" and we have "Food for Victory" campaigns.

Primitive man was a hunter. Forest, field and stream

were his hunting grounds. It was a precarious existence and most of his energy was spent in hunting food for himself and keeping from becoming food for other animals. Life was hard and hunger his constant companion. As a result, primitive life was in large measure an individual struggle in which man fought man and animal for Nature's scanty and uncertain bounty. Then man learned to domesticate animals, assuring himself an expanded and more regular supply of food. The nomadic, or pastoral, life encouraged men to cooperate. Families banded together into tribes for self-protection and the safety of their herds and flocks. Such an existence, however, was still far from secure and the tribe was forced to move continually to provide new pastures for its animals.

It has been said that civilization began with the introduction of agriculture. Certainly the most ancient civilizations of which we have record, those of Egypt, China, Greece and Rome, were based on an agricultural food supply. With cultivation of the soil, man's life acquired a new aspect. The total of each man's energy and thought ceased to be necessary for securing his own food. With permanent homes, families became neighbors and in the time retrieved from agriculture, society developed. With society came specialization and government. Since food for a group could be provided by a portion of its members, by organization each one could work at the task he could do best. With the greater efficiency of specialization, still more "leisure" time was obtained and the cycle of expansion repeated again and again. It is difficult for an individual living in the twentieth century to grasp the significance of this advance in the mode of human existence. The profoundness of the change is hidden by the long interval and obscurity of its happening and the changing civilizations resulting therefrom.

Only in the past 150 years have civilized peoples been released from the fear of famine. Abundant food supplies are one of the hallmarks of our modern society, the result of an adjustment in our civilization termed, in popular

parlance, the Industrial Revolution. Fundamentally, it resulted from man's learning different ways to harness sources of power and energy. Man's mastery of the engineering sciences in the development of machines has provided a means of victory in the conquest of hunger. In the short span of 15 decades the impetus of industrialization has resulted in greater increases in population and progress in civilization than occurred in as many centuries.

The Beginnings of Science

Originally, man was a true child of nature and subject to all the vagaries of his environment. However, having powers of intellect not granted to other members of the animal kingdom, he learned to improve on Nature's provisions for him by controlling his environment. The extent to which this has been accomplished is the measure of his progress.

One of the earliest conquests of nature was the discovery of fire. Soon, probably by accident, man found that cooked food was easier to eat and had a more pleasing taste. (Although he did not know it, the cooked food was more sanitary.) Observations early taught him to dry surplus meat in the smoke of his fire and to gather extra amounts of wild grains and store them in his cave. In the thousands of years following, the problem of food supply was the only aspect of nutrition in which any progress was made. Crude methods of preservation, smoking, drying and pickling, were developed, crops were grown for winter use and animals were raised for their meat and hides. Practical arts were acquired as necessity dictated. He learned to make crude weapons and tools with which to kill game, build shelters, harvest grain and make clothing. The only other progress made in learning was the development of languages and counting, whereby man measured his wealth. Knowledge was accumulated only by word of mouth and few individuals lived long enough to acquire the knowledge of parent or teacher,

add to it and then pass on the total to a member of the next generation.

The advance of science is based upon recording observations and discoveries so that the student may grasp the knowledge available and extend it for the benefit of students of the same and following generations. We know the hieroglyphics of Babylonia back to 3500 B.C. and those of Egypt to 2600 B.C. They have contributed information of incalculable value to students of the present but these records are probably of greater value to the generations of today than they were to the generations who wrote them. The Phoenicians used the first phonetic alphabet in the fourteenth century before Christ, transcribing their messages on clay and baking the tablets to preserve them. For the first time man could put his thoughts as he spoke them on recordings from which others could derive an identical thought. Thus, succeeding generations of students could acquire the knowledge gained in the past, add to it, and record their own observations for posterity.

But phonetic writing did not accelerate appreciably the advancement of science. True, the thinkers of those times could count their wealth and transcribe their observations and speculations, but stone and clay tablets (stele) were fragile as well as heavy and a journey of only a hundred miles was strewn with hazards and might take weeks. It was not until after papyrus came into general use that we have records of organized attempts to compile and integrate the observations of different individuals, although one of our most valuable records of the second century before Christ, the Code of Hammurabi was inscribed on steles.

Papyrus, made from the pith of a tall marsh-grass prevalent in Egypt and nearby countries, was in common use in the fourth century before Christ. There were no formal subdivisions of philosophy, the love of wisdom, except as each philosopher developed his particular interests. The thoughts and observations of the great philosophers were copied on the papyrus fiber scrolls and distributed through-

out the civilized world. (Parchment, prepared from the skin of animals, was also in use during this period.) In this period the profound mysteries of the heavens had established astrology as the master subject of philosophers. The intricacies of man's immediate environment were investigated by the speculative philosophers (alchemists) and students of natural philosophy. From astrology have come higher mathematics and astronomy; from alchemy the science of chemistry evolved; and, from natural philosophy we derived physics and biology.

Graham Lusk (1) tells that although the Ebers Papyrus (1552 B.C.) advises a diet of cakes, grits and wheat "to drive away the too much emptying of urine" (believed to be a reference to diabetes), it was not until more than one thousand years later that the Greek physician, Hippocrates, gave credit to problems of nutrition for the development of medical knowledge when he stated: "Let us inquire therefore what is admitted to be medicine. . . . To me it appears . . . that nobody would have sought for medicine at all, provided the same kinds of diet had suited with men in sickness as in good health."

Thus, in the fifth century before Christ, Hippocrates accumulated the observations of others with those he made himself and prescribed a mode of living to prevent disease, and substances which could be eaten to cure or help specific conditions. This famous Greek who has been immortalized as the Father of Medicine demonstrated the *application* of knowledge to prevent and cure disease and lengthen the span of human life. Hippocrates' emphatic writings on diet, fresh air and sunshine constitute the earliest recognition of the importance of what we now term nutrition. He predecessed modern measurements of energy metabolism when he said: "Growing bodies have the most innate heat; they therefore require the most food for otherwise their bodies are wasted. In old people the heat is feeble and they require little fuel, as it were, to the flame, for it would be extinguished by much." He also knew the value of "medicinal

waters," principally those which would prevent "big neck" (goiter), and was familiar with crude surgery.

The knowledge of the centuries before Christ and of about 1400 years following His birth consisted almost entirely of those phenomena which could be distinguished with the senses, i.e., could be seen, felt, tasted, heard or smelled. As Western civilization spread beyond the shores of the Mediterranean Sea and the complexities of living increased, universities were founded so that the knowledge of one learned man might be passed to many students and at the same time each student could learn from an entire group of teachers.

From a microscopic amount of exact information and a thousandfold of misinformation all of our scientific knowledge has accrued in the past 15 generations. It is not strange that the launching of the "Age of Science" occurred simultaneously with the development of printing from movable type, nor that the continually increasing momentum of science has paralleled the development of printing. With this incredibly fast method of transmitting words the knowledge of the entire world was brought within the reach of every man. Copies of books could be printed by the hundreds as easily as one could be transcribed by hand—and all copies would be alike. They could be transported easily and if a few were lost it was no great matter. It was only one more step to scientific periodicals which would distribute information almost immediately after it was obtained.

Modern science represents the triumph of mind over matter. To a greater degree than anything in the previous history of the human race, it places men apart from other members of the animal kingdom. The vast and imposing collection of ordered knowledge of natural phenomena and the accelerating pursuit and discovery of that which remains unknown have given us the means of advancing our material welfare to a level beyond the dreams of even our immediate forefathers. Besides the printed word, which allows the thoughts and ideas of past thinkers to be carried into the future, as well as rapid dissemination of knowledge as it

accumulates, other forms of communication have provided for a wide and even quicker interchange. The steamboat and the steam train, the automobile and the airplane, the telephone, telegraph and radio have annihilated time and space and made neighbors of every country and race on the surface of the earth. These rapid means of transportation and communication have brought world problems into focus in terms of humanity in general, replacing the limited perspectives of the past.

The Foundations of Nutrition

Primitive man was ingenious and adept in securing food, but other than satisfying the hunger pangs of his stomach and certain superstitious beliefs one food appeared to him as good as another. Peoples have always naively believed that their own virtues could be increased by consuming the organs of their neighbors, for example, that eating the heart of an enemy would enhance courage and fighting strength. The application of this same concept to the cure of certain diseases was less fantastic. Thus, in the time of Hippocrates such prescriptions as wolf's liver for liver disease, rabbit's brain for nervousness, and fox's lung for respiratory disorders have their modern counterparts in present-day opotherapy (organ therapy) such as the treatment of anemia with liver, and goiter with thyroid gland substance. Nevertheless, Hippocrates propounded the view that all natural foods nourished the body by virtue of containing a single specific nutrient principle or "Aliment." William Beaumont, the U. S. Army surgeon who pioneered in studies of gastric digestion, in 1833 still retained this ancient doctrine of a "universal nutrient" in food.

In the short period of twenty-six years, carbon dioxide was discovered by Black (1757), hydrogen by Cavendish (1766), nitrogen by Daniel Rutherford (1772), oxygen by Priestley (1774), animal calorimetry by Crawford (1779), and the composition of water by Cavendish (1783). It remained, however, for the genius of Lavoisier to fit all of

these isolated discoveries into a completed whole and explain the process of oxidation and draw the corollary with respiration in the animal body. This brilliant French chemist, father of the Science of Nutrition, used the thermometer and the analytical balance in studies of animal metabolism. Lavoisier and Laplace put guinea pigs in a chamber surrounded by ice and from the amount of ice melted in a definite period of time they measured the heat given off by the animals. Thus began the work which eventually lead to the energy concept of food and the evaluation of different foods on the basis of their energy value, or the amount of fuel they furnish to the body. His work is summed up in his statement: "Life is a chemical function."

Early in the nineteenth century the French physiologist Magendie (1783–1855) had initiated the biological method of food analysis, which is the basic tool of the Science of Nutrition. He took dogs, gave them water, and fed them on sugar alone, or butter, or olive oil. The dogs died in two to three weeks. He added gelatin to the sugar-and-fat diet of his dogs, but found that it would not substitute for meat. He demonstrated that foodstuffs differed in their nutritive properties and differentiated between nitrogen-containing and non-nitrogen-containing foods. Nevertheless, it remained for William Prout (1785–1850), the English physician who discovered "free" hydrochloric acid in the gastric juice in 1823, to propound the modern view that food must furnish not one but several kinds of nutrient substances (1). In his classic book (2), published in 1834, he stated: "a diet to be complete, must contain more or less of all the three staminal principles"—three kinds of foodstuffs, namely, the saccharine, the oily and the albuminous, or, in modern terminology—carbohydrate, fat and protein.

By the middle of the nineteenth century the fact that all foods did not play identical parts in nutrition was being recognized. Pereira (1843) stated that the staminal principles and water were not enough and believed that certain minerals such as salt were just as essential to life as nitrog-

enous or non-nitrogenous food and water. He further pointed out that lemon juice did not owe its nutritive value to its content of sugar, protein, fat, or water. At this time the great German chemist Von Liebig (1803–1873) was working out the chemical analysis of foods and the German physiologist Voit (1831–1908) was beginning his studies on the energy needs of the body. Thus, at the end of the nineteenth century (1895) the American scientist Atwater (1844–1907), published a summary of the important phases of nutrition in relation to food, stressing the chemical composition of the materials used for the food of man; the proportions of nutritive ingredients; their digestibility; their fuel value; the ratios between their values in nutriments and their costs; the kinds of food and proportions of nutrients best adapted to the demands of people of different classes and occupations; the errors in our food economy; and the sociological and agricultural bearings of the subject. These constitute a cogent statement of the nutrition problem in terms of the foods we eat. With the possible exceptions of fuel value and digestibility these same problems are as acute today as they were fifty years ago, but in different and more refined aspects. The chemical analyses to which Atwater referred in speaking of composition of food materials were more than crude in terms of present chemical and biological techniques of analysis. Atwater did not know about vitamins, those elusive chemical substances which in amounts hardly visible to the eye constitute the difference between a health-promoting and a deficient diet.

At that time students of nutrition believed the digestible parts of natural foods consisted only of protein, carbohydrates (starch, sugars), fats, and ash (minerals). These constituents could be determined in the chemical laboratory and the results of such analyses generally indicated that very nearly all of the food material used in the body was accounted for as protein, fat or carbohydrate. Under these conditions fruits, fresh vegetables and eggs were expensive foods to eat if the cheapest of foods would supply the need. The main

fault with this concept was the lack of the knowledge essential to its success. Today we are evaluating foods on a *cost per nutriment* basis, i.e., efficient food production and utilization in terms of nutriment yield rather than volume or market value. The greatest single factor in this advance has been the recognition of the quality factor in foods, which has resulted from the application of the *biological response* method of investigation.

Nutrition—A Twentieth Century Science

In America, nutrition came into being and reached adulthood within the life span of one man, who died while this manuscript was being prepared. Russell Henry Chittenden had been for many years Director of Sheffield Scientific School at Yale University. In 1878, after Chittenden had been to Germany to study the application of chemistry to physiology, he returned to establish the first department of physiological chemistry in this country. Hundreds of the students trained by Chittenden and his immediate followers are now established in various educational and research institutions and have served as a nucleus out of which the science of nutrition has sprung in America. One of the earliest descriptions of nutrition is that presented by Chittenden (3) in *The Nutrition of Man:*

> One of the great mysteries of life is the power of growth, that harmonious development of composite organs and tissues from simple protoplasmic cells, with the ultimate formation of a complex organism with its orderly adjustment of structure and function. Equally mysterious is that wonderful power of rehabilitation by which the cells of the body are able to renew their living substance and to maintain their ceaseless activity through a period, it may be of fourscore years, before succumbing to the inevitable fate that awaits all organic structures. This bodily activity, visible and invisible, is the result of a third mysterious process, more or less continuous as long as life endures, of chemical disintegration, decomposition, and oxidation, by which arises the evolution of energy to maintain the heat of the body and the power for mental and physical work.
>
> These three main functions constitute the purpose of nutrition . . . Development, growth, and vital activity all depend upon the availability of food in proper amounts and proper quality.

In celebrating the 50th Anniversary of the American Physiological Society, in 1938, Howell (4) states that:

> From Galen to Lavoisier physiology won its chief victories by the use of the experimental method, but it did not become established as a separate experimental science, after the pattern of physics and chemistry, until well into the Nineteenth Century. Its foundations were laid, roughly speaking, in the second quarter of the century, largely by the work and influence of Johannes Müller in Germany and Magendie and Bernard in France. Other European countries followed this lead in due course of time. In the United States there were individual workers who soon felt the influence of the new movement, but the full recognition of physiology as an independent science, with laboratories and techniques of its own and facilities for the training of specialists in the subject, did not occur until the latter part of the seventies, when nearly simultaneously three such laboratories were organized, one at the Harvard Medical School under Bowditch, one in the Graduate School of the Johns Hopkins University under Newell Martin, and one a little later in biochemistry, or physiological chemistry as it was then called, in the chemical department of Yale University under Chittenden.

In earlier civilizations all knowledge could be comprehended as philosophy. As facts replaced mysticism and conjecture some branches of science developed to explore the natural laws of the universe and their working, others to apply the knowledge available so that man might benefit. Thus, physics, chemistry, biology, and mathematics arose and delved into the phenomena of nature from different directions. With the progress of experimental methods of study these exact, or fundamental, sciences ceased to be independent of each other and new sciences were formed by combining parts of two or more of the earlier ones.

Today, the fundamental and applied sciences involved in nutrition could be subdivided into scores of branch and supporting sciences. As each science has expanded, its enthusiasts have been forced into ever narrower fields of specialization. In turn, scientists working in different specialties have pooled their efforts to obtain a composite picture of a single aspect of life and, frequently, have created a distinct field of endeavor. In its development, application, and

progress the science of nutrition embraces most, if not all, of the sciences. Even theology is involved, indirectly, by its association with psychosomatic relationships which are intimately involved in nutrition.

The new science of nutrition utilizes the combined knowledge of fundamental and applied science (Figure 1). Nutrition research is conducted in the laboratories of hospitals, schools, manufacturers and food processors—with human

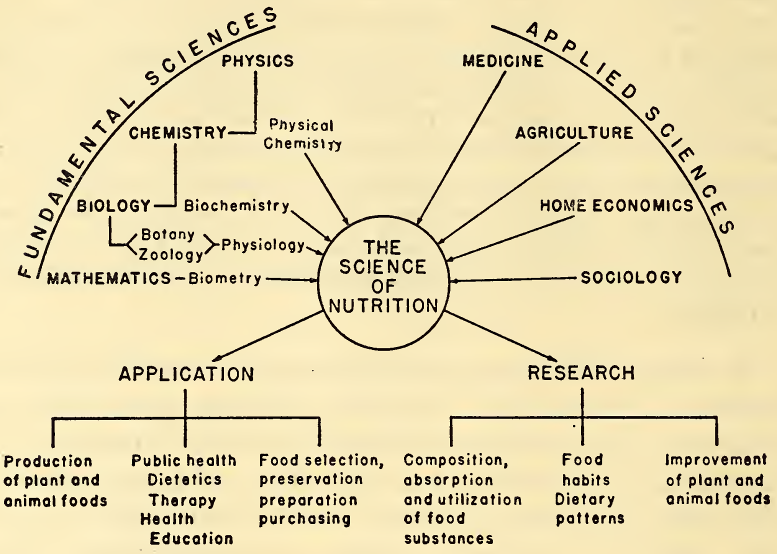


Fig. 1.

subjects, animals, plants, and microorganisms—by chemists, biologists, physiologists, biometricians, physicians, home economists, sociologists and agriculturists. The training given in most of our science courses may be employed in either nutrition research or the application of the newer knowledge of nutrition. The accompanying diagram provides a partial list of the individuals whose notable contributions to the science of nutrition in the United States have resulted from interests and training in various fundamental and applied sciences (Figure 2).

This new science of nutrition is a result of classic investi-

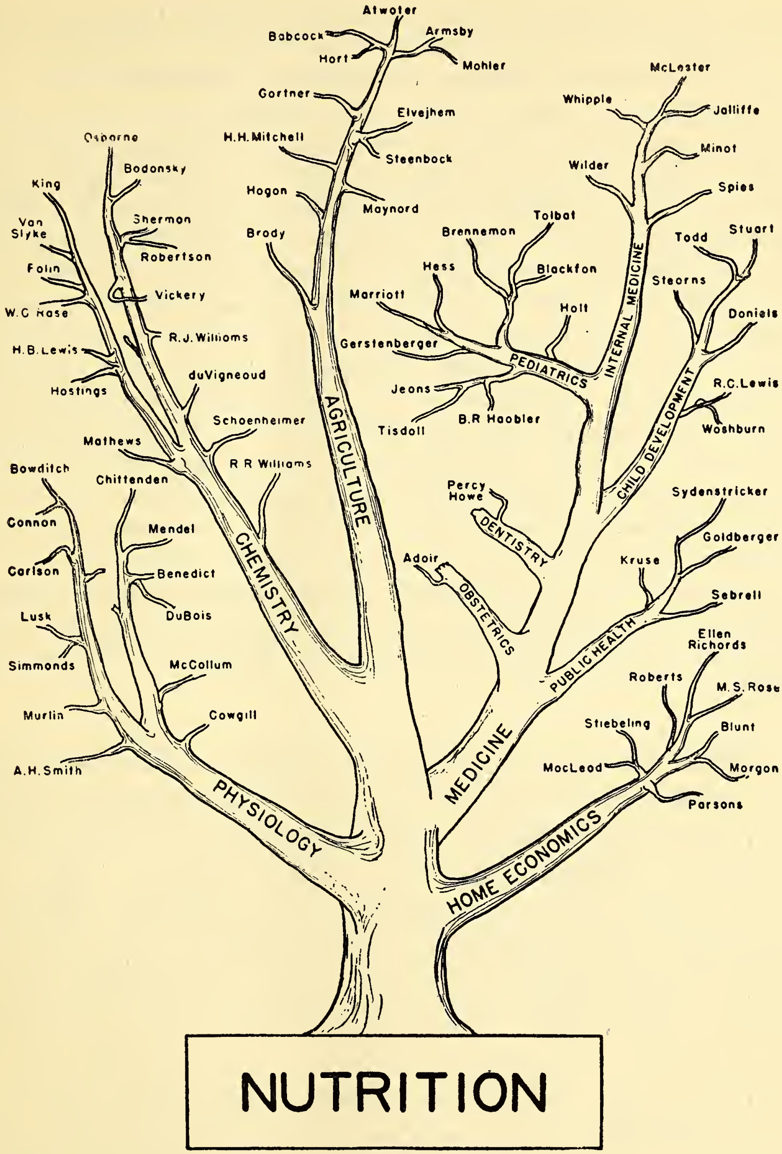


FIG. 2.

gations which were tersely summarized by the late Mary Swartz Rose (5):

Through Lavoisier's brilliant insight into the relation between the intake of oxygen in respiration, the output of carbon dioxide from the

lungs, and the evolution of heat and work in the body; Liebig's study of the composition of foods and body materials; Rubner's accurate researches establishing definite relationship between food consumption and body activity; Eijkmann's demonstration that a specific disease may be produced by one diet and cured by another; Hopkins's brilliant conception of subtle elements in food regulating nutritional processes; Osborne and Mendel's control of growth through changes in the quality of a single chemical component of the dietary; McCollum's finding that old age may be deferred through a well-assorted diet; and Sherman's demonstration that a good diet can be made better by simple changes in natural foods, as shown by more rapid development of the young and greater vigor and a longer "prime of life" in adults—through the work of these and other able investigators, we have come to the realization that nutrition is science rather than a bundle of old wives' rules; that foods, though so numerous and so varied in form, can be reduced to rather simple terms; that the amount required by a man for a day's work can be determined with amazing accuracy, and that even the factors which govern the power to develop can be analyzed and a young animal made to grow or be stunted at will by the control of its food. Scientists in many laboratories are studying the laws which govern nutrition, and as they progress in knowledge the housewife is given new standards by which to choose the food for the family.

Before the Civil War only one federal department, the U.S. Public Health Service, was concerned with promoting the health of the Nation. That department was interested, largely in sanitation measures—which today is only one phase of its activities. Although the American Medical Association was established in 1847, physicians of that time limited their activities to the treatment of ailments rather than their prevention. Even in the midst of the pressures of the Civil War, Land Grant Colleges were established under the Department of Agriculture (1862) and President Lincoln approved (1863) the act of Congress which established the National Academy of Sciences to " . . . whenever called upon by any department of the government, investigate, examine, experiment, and report upon any subject of science or art . . . " After the War Between the States the nation embarked upon a period of scientific development unprecedented in history.

In the course of the economic adjustments during the years following the Civil War, women were admitted to the Land Grant Colleges (1870) and in 1874 technical training in home economics was made available. In the latter year, also, the *American Chemical Society* was founded. In 1887 the United States Department of Agriculture established Experiment Stations throughout the country. The next year both the *American Pediatric Society* and the *American Physiological Society* were founded. The annual conferences at Lake Placid, New York, called by Ellen Richards from 1899 to 1909, firmly established home economics as a field of science and emphasized the necessity of training women in that and other sciences. Out of these conferences came stimulation of nutrition research and, in 1912, the *American Home Economics Association.*

The augmented knowledge of basic science, the increased acceptance of its value, a growing participation in academic and scientific fields by women and the economic progress of the Nation made expanded scientific efforts inevitable. Early in the century the groups representing medicine and its fundamental sciences were well organized, their memberships growing rapidly, and their voices were affecting greatly the beliefs and opinions of the rapidly enlarging population.

There is a tendency for the membership of scientific societies to subdivide into small groups, each with particular interests, wherein they can talk about their special problems in language which others might have difficulty in understanding. Of the *American Physiological Society*, Howell (4) says:

> In the beginning the programs of the meetings covered the whole range of the medical sciences, experimental physiology, physiological chemistry, histology, pharmacology and pathology. It did not seem to be difficult for an average member to listen with profit to reports of work done outside his immediate bailiwick. But with the increase in number of scientific workers, and the growing specialization in problems and in technical procedures, divisions of interest became more apparent. The chemists were somewhat restive under a barrage of papers on experimental physiology, and the physiologists were lost, perhaps, in the

intricacies of a chemical discussion. The device of growing papers on the program did not wholly satisfy the desire of specialists to get together over their own problems, and there arose a tendency to segment into groups.

The first major division of this kind to occur was the formation of a society of biochemists. . . . In . . . 1906 Dr. Chittenden announced to the Society the fact of the organization of *The American Society of Biological Chemists*, and expressed the hope that its relations with the Physiological Society would be most cordial, and that no conflict of interests or purpose would be allowed to rise. Inasmuch as the leading members of the new society were all active and influential members of the Physiological Society it was a matter of regret for some of the members to see this separation consummated.

Indeed, it is said that some members felt so keenly about the separation that on the return train trip home from Philadelphia to New York few were on cordial speaking terms. As a matter of fact there was no conflict of interest. The two societies arranged to hold their annual meetings together and acted in close affiliation on matters of common concern.

Coincident with the developments in physiology, chemistry and medicine, and the progress of the home economics group, nutrition was becoming the major interest of a growing group of scientists. Chittenden published his *Physiological Economy in Nutrition* (6), in 1904, and in 1907, *The Nutrition of Man* (3). In the first textbook on nutrition published in this country, *The Science of Nutrition* (7), Graham Lusk in 1906 defined his subject as "the sum of the processes concerned in the growth, maintenance and repair of the living body as a whole or of its constituent organs." In 1911 H. C. Sherman published the first textbook of a still-growing list of important contributions to the development of the science of nutrition. This volume, *Chemistry of Food and Nutrition* (8), was followed by *Food Products* (9), in 1914. In 1912 Mary Swartz Rose published a *Laboratory Handbook for Dietetics*, followed by *Feeding the Family* (10), in 1916. *The Newer Knowledge of Nutrition* (11), by E. V. McCollum, appeared in 1918. In 1923 the late Lafayette B. Mendel,

most illustrious of Chittenden's pupils and himself a revered scholar and teacher, defined nutrition with comprehensive simplicity in his book titled *Nutrition—The Chemistry of Life* (12).

In 1912 the *American Physiological Society*, the *American Society of Biological Chemists* and the *American Society for Pharmacology and Experimental Therapeutics* united to form the *Federation of American Societies for Experimental Biology*. In the same year the *American Chemical Society* established a Division of Biological Chemistry. The tremendous impetus given to exact and applied science during World War I resulted in the organization of the *American Dietetic Association*, in 1917, and in 1918 Frances Stern established the first clinic for the dietary care of outpatients. The clinic, the Boston Dispensary Food Clinic, was the initial step in organized medical application of the knowledge provided by the science of nutrition; the methods initiated there are now used in over 50 similar clinics.

It is a cruel paradox of war that despite the destruction of human life and property, the wastage of human values and material resources, and the subjugation of spiritual and moral virtues, there is produced an acceleration in basic contributions to the material welfare of humanity. Unfortunately, but true, wars more than anything else have a unifying effect on the people. The fight against the common enemy calls forth the greatest effort and things are done because they must and should be done. In the United States the first major impetus toward public health efforts and experimentation in the fields of nutrition research and food control and improvement accompanied the Civil War. The energy, or fuel, requirements of the body were first studied by accurate measurements at the turn of the century. The period of World War I brought emphasis upon completeness and precision in studies of substances of which our bodies are composed and the quantity in which we need them in our daily food. During the past thirty years, development in both these directions, together with a rapid series of discoveries

about the vitamins, trace minerals, lipids (fats) and amino acids (protein constituents), form the period of what McCollum has termed "the newer knowledge of nutrition." H. C. Sherman has said that "while the obvious outward mark of the period of this newer knowledge is the discovery of the vitamins, it is also noteworthy that the science of nutrition is evolving a fundamentally new viewpoint. This centers in the fact that what one takes in as food, even within the range of everyday normal conditions, may influence the body's internal chemistry much more significantly than hitherto supposed."

The *Eastern Society for Pediatric Research* was organized in 1928 and in 1932 became the *Society for Pediatric Research*. In 1931 the *American Medical Association* established within the Council on Pharmacy and Chemistry (1905) a Committee on Foods and Nutrition. By 1936 the work had gained such importance that it became a separate Council on Foods and Nutrition. *The Society for Research in Child Development* was organized in 1933, through the influence of the Rockefeller Foundation and the National Research Council.

With the great stimulus and inspiration from the rapidly expanding research in nutrition there was the budding of the *American Institute of Nutrition* and its segregation from the *American Society of Biochemists* and the *American Physiological Society*, in 1934. Although organized and incorporated in 1928, primarily for the purpose of publishing a journal devoted to the science of nutrition, this new scientific society applied for membership in the *Federation of American Societies for Experimental Biology*. Its request was denied until 1940, when it had demonstrated that its membership was made up of bona fide scientists and plans for enlarged activities were complete.

Private Support of Science

The efforts by government and by organizations of individuals toward scientific advances in public health, agriculture, education, and social organization have been supplemented

TABLE 1

PUBLIC TRUSTS IN THE UNITED STATES*

Name	Year Founded	Amount Expended to 1944
The Rockefeller Foundation	1913	$ 329,682,371
General Education Board	1902	264,692,780
Carnegie Corporation of N.Y.	1911	187,262,199
Charles Hayden Foundation	1937	6,500,000
Julius Rosenwald Fund	1917	17,673,420
Russell Sage Foundation.	1907	20,650,000
The Buhl Foundation	1928	4,201,820
Children's Fund of Michigan	1929	9,904,272
Carnegie Endowment for Int'l Peace	1910	19,644,532
Carnegie Foundation for the Advancement of of Teaching	1905	44,424,603
Carnegie Institution of Washington	1902	49,491,751
Commonwealth Fund	1918	41,768,102
Spelman Fund of New York	1928	12,493,149
Maurice and Laura Falk Foundation	1929	1,983,055
Z. Smith Reynolds Foundation	1936	1,480,829
Cranbrook Foundation	1927	11,766,022
Carnegie Hero Fund Commission	1904	6,386,878
John Simon Guggenheim Mem'l Foundation	1925	2,662,000
John and Mary R. Markle Foundation	1927	7,575,622
Milbank Memorial Fund	1905	12,445,924
Permanent Charity Fund	1915	5,048,573
Kresge Foundation	1924	2,686,232
Daniel and Florence Guggenheim Foundation	1924	2,835,739
W. K. Kellogg Foundation	1930	15,753,741
New York Foundation	1909	5,398,799
Phelps-Stokes Fund	1911	1,962,561
Alfred P. Sloan Foundation	1936	2,215,800
Cleveland Foundation	1914	2,915,873
Woodrow Wilson Foundation	1922	353,578
Chicago Community Trust	1915	2,820,000
Total	....	$1,094,680,225

* From *The World Almanac*. New York World-Telegram, 1944.

by industrial and commercial research and development, largely from economic motives, and also by private philanthropies devoted to the public interest. The majority of the latter are projected into specific channels which express the interest of their sponsors, and permit projects which could not be inaugurated by public agencies, yet make a tremendous contribution on behalf of society. Frequently, a public trust established by private funds, by unhampered pursuit of a single objective, may demonstrate possibilities which would otherwise be unknown. The benefits which have accrued to the nation from public spirited individuals are indicated by the amounts which some of the public trusts in the United States had spent preceding 1944 (Table 1).

The advent of World War II flung a challenge at the resources of the Americas to assure good nutrition for servicemen of all races, types and nationalities and to improve the nutrition of the civilians of allied and occupied countries. The necessities of the war furnished the stimulus for renewed attacks, greatly expanded and unhampered by restricted funds, upon many problems of nutrition. Whereas previously application of new facts lagged far behind acquisition, during the war discoveries were immediately applied on behalf of the armed forces and the production army. Today, knowledge is available which, applied at the human frontier, can promote peace on earth and good will among men.

Chapter Two

NUTRITION AT THE HUMAN FRONTIER

When dollars and cents are involved, people act quickly; but in matters of health and human welfare, terrific emergencies are required to rouse them from their lethargy. The large numbers of men rejected in World War I was of only temporary concern. There was much talk at the moment about the causes of physical and mental unfitness among the men of military age, but no concerted plan was made to improve the situation. After the Versailles treaty was signed, Americans complacently settled down to solve the problems of mechanical reconstruction presented by the war of destruction. They became so enamoured with mechanization that they gave full measure of their time, money and effort to developing a great mechanical age and thought little in terms of human welfare values.

White House Conference on Child Health and Protection

The war clouds again began to gather in 1930. The United States became alert to the fact that war might involve our children and our children's children. The future manpower became the concern of the nation. Interest was focused upon the value of accumulating a "stock pile" of men for military and industrial use. President Hoover called upon the experts of our nation to pool their efforts in making an evaluation of the resources available and methods to increase them. Several hundred specialists in maternal and child care were invited to attend the deliberations of the White House Conference on Child Health and Protection. After the meetings in May, 1930, those in attendance were sent home to work as they had never worked before, digging out and summarizing all the known scientific facts in these important fields of human welfare.

After months of fact-finding by dozens of experts in every conceivable line of activity, it was revealed (later, the formal report required 32 volumes) that a shamefully large number of the children of the United States were handicapped by physical and mental unfitness; that many of the stamps of inferiority being placed on children—the worker and soldier prospects of World War II—were preventable if the newer knowledge of science were applied; that infant and maternal mortality and morbidity were too great because some doctors did not have sufficient training in the techniques of delivering babies and because there was inadequate knowledge of the food women should eat and the nutritional care mothers should have during pregnancy and lactation.

The late Dr. Kenneth D. Blackfan (13), chairman of the Committee on Growth and Development, summarized the findings on nutrition:

> Nutrition, while properly a branch of physiology, stands in a somewhat unique position, because of the immediate and pressing character of the problems with which it deals. Here we may perhaps justly feel that the first phase of a large task has been successfully completed, in that we possess a sufficient body of well-established facts and interpretations to be able to construct an adequate diet for children of various ages, both in respect to material necessary for growth, and fuel to supply the necessary energy. As a result, several diseases and disorders of nutrition have been overcome. Infantile scurvy is rapidly becoming a thing of the past, and rickets could be practically eradicated if our present knowledge were universally applied. The problem of rickets has now become one of education and administration more than one of laboratory research. The first phase of the problem of nutrition, we repeat, seems to have been completed; but it is possible that history is going to repeat itself. A generation ago nutrition workers felt in the same comfortable position, and then came the discovery of the vitamins. Now, while taking advantage in a practical way of the additional knowledge gained in the last thirty years, we must ask ourselves certain fundamental questions: Are all of the necessary constituents of foods known to us at last? Are there perhaps one or two vitamins whose existence has not yet been detected? Are small quantities of certain minerals such as copper possibly essential for proper growth? And are there perhaps certain other chemical compounds needed by the body which the animal body is unable to make for itself? Are there certain unsuspected inter-relationships and perhaps

antagonisms between some of the recognized constituents of foods? To answer such questions as these calls for a most extensive and carefully planned series of experiments upon laboratory animals, not only of one but of several species.

Turning now from these fundamental problems of the laboratory we find a whole series of problems of a more practical nature. These begin with the necessity for a still more careful determination not only of the quantity, but also of the quality of food which is needed by children of various ages. We may sum these questions up perhaps, by stating that we must determine the necessary minimal quantities of the various constituents of the diet, to what extent various foods can be substituted one for another. There is also an extremely important question at the other end of the scale: What about the maximal quantity of total food or of particular kinds of food which it is desirable to feed children? Is the biggest baby necessarily the best? Are there dangers in overfeeding concentrated preparations of vitamins or other materials which may be essential in small quantities? To answer those questions requires a most careful study of children under various circumstances, to supplement the findings of the laboratory.

* * *

There is also a complicated inter-relationship between poor nutrition and chronic fatigue, which must be elucidated and the relative importance of each factor evaluated. It seems quite probable that in answering these questions we may find also the answer to the question, to which we have already referred, of why we find among children of early school age such a high incidence of poor posture and body mechanics. All of these are problems requiring careful study in the future, and which seem to be susceptible of attack by methods at present available and on the basis of present fundamental knowledge. They also illustrate the necessity for cooperation between workers trained in different fields and concerned with different aspects of the child. The physician must enter into close cooperation with the dentist, the school teacher, and the orthopedic surgeon.

Another striking illustration of the relationships of nutrition with other aspects of the child is found in the important part which psychology plays in adequate nutrition. The chapters of our report dealing with this subject point out that the problem of lack of appetite in children which is so frequently met with by practitioners may often be a purely psychological problem and not one of nutrition or organic disease, and that to handle such problems successfully the doctor must treat from the psychological point of view not only the child but the child's parents as well. In order to meet his full obligation the

practitioner of the future must be acquainted with the principle of practical psychology and habit training. Closely related with this is the important question brought to light by recent experimental work, as to the extent to which natural appetites of children may be sound guides as to what the child should eat and how much. It may be that we have in nature a stronger ally in dealing with the problems of nutrition than we have been wont to recognize.

* * *

In short, we must proceed with the experience of the race as our fundamental guide in this difficult problem of adapting our children to meet the exacting conditions of modern civilization and not embrace with undue haste the results of partially evolved theory. And in all of our discussions of what is best for children we must not overlook the priceless heritage of a happy home.

At this White House Conference in 1930, Dr. Fred L. Adair (14), Chairman of the Committee on Prenatal and Maternal Care, reported that

. . . the mother is the life of the family insofar as child health and protection are concerned. We all realize that there is a wastage of maternal lives due to controllable causes operating in connection with child-bearing and that our country lags behind the civilized world in the prevention of these deaths. . . . The loss of the mother in childbirth is a disaster, not only to the newly born infant should it survive, but also to the other children in the family, if there be such. Not only are our maternal, fetal and neonatal death rates too high, but there has been little, if any, decrease in the last decade, which is discouraging. This becomes of added importance to communities and States because the birth rate is declining, which means that our human assets are becoming relatively more important. The failing birth rate is affecting particularly the families of our leaders, which is unfortunate and demands the preservation of these infant lives to as great an extent as possible.

* * *

President Hoover in his address on November 19 at the Conference on Child Health and Protection, stressed the fact that there are in this country 14,000 children who are totally and 50,000 who are partially blind. Many of these can trace this condition to syphilis and gonorrhea, which can be practically eliminated as causes of blindness in infants and children by adequate prenatal and postnatal care. There are 300,000 crippled children, many of whom can date their disability to birth. Some of these conditions are congenital and could not be avoided. In

others the deformity has resulted from birth injuries which have affected the central or peripheral nervous system, the muscles, bones or joints. It would not be possible to avoid all of these casualties, but the better the obstetric care the fewer there will be. Appropriate postnatal care would bring many of these conditions to light so that prompt measures could be instituted for their correction. . . . The loss of the mother has undoubtedly been a contributing factor in the production of the 200,000 delinquent and 500,000 dependent children, and inadequate maternal care comes in for its share of blame as a cause for the 450,000 mentally retarded children and of the 670,000 presenting behavior problems. . . .

Hereditary and congenital factors as well as birth causes and postnatal conditions enter into the production of the groups mentioned above. Many of these conditions are caused directly or indirectly by complications arising and affecting mothers during pregnancy and parturition. It is impossible to ascertain how many of the problems presented by these large groups of children could have been prevented by the proper application of the principles or prenatal, intranatal, and postnatal care, but certainly many of them could have been avoided.

The provision of proper nutrition of the infant begins immediately after birth and presupposes a mother who has been properly prepared during pregnancy for nursing her baby and also makes provision for proper postnatal nourishment in case the natural supply is inadequate. Many of these children doubtless suffered from the handicaps of prematurity and lack of the special care required for such infants. Many may have suffered from lack of the proper maternal care which may have arisen from a variety of causes. . . .

* * *

Prenatal care of adequate degree must be followed by competent intranatal and postnatal care for the health and protection of both mother and infant. In order to accomplish these, it is necessary to have properly trained and educated doctors, nurses, midwives, dentists, social workers, mothers, the laity, and others who come in contact with the problems of maternity and infancy.

In addition it is necessary that proper organizations be set up in various communities, that the necessary institutions be established and the essential personnel be supplied. Luxuries are not lacking in this country, surely it is not a luxury to prevent morbidity and mortality among mothers and infants. Perhaps we are becoming too easeloving and self-satisfied and maybe losing some of our sense of proportion and ideas of fundamental values.

The doctors individually and collectively should lead in these movements to secure the health and protection of both mothers and infants. We should apply and disseminate our present knowledge and our basic

The Children's Charter

President Hoover's White House Conference on Child Health and Protection recognizing the rights of the child as the first rights of citizenship pledges itself to these aims for the children of America

I. For every child spiritual and moral training to help him to stand firm under the pressure of life.

II. For every child understanding and the guarding of his personality as his most precious right.

III. For every child a home and that love and security which a home provides; and for that child who must receive foster care, the nearest substitute for his own home.

IV. For every child full preparation for his birth, his mother receiving prenatal, natal, and postnatal care; and the establishment of such protective measures as will make child-bearing safer.

V. For every child health protection from birth through adolescence, including: periodical health examinations and, where needed, care of specialists and hospital treatment; regular dental examination and care of the teeth; protective and preventive measures against communicable diseases; the insuring of pure food, pure milk, and pure water.

VI. For every child from birth through adolescence, promotion of health, including health instruction and a health program, wholesome physical and mental recreation, with teachers and leaders adequately trained.

VII. For every child a dwelling place safe, sanitary, and wholesome, with reasonable provisions for privacy, free from conditions which tend to thwart his development; and a home environment harmonious and enriching.

VIII. For every child a school which is safe from hazards, sanitary, properly equipped, lighted, and ventilated. For younger children nursery schools and kindergartens to supplement home care.

IX. For every child a community which recognizes and plans for his needs, protects him against physical dangers, moral hazards, and disease; provides him with safe and wholesome places for play and recreation; and makes provision for his cultural and social needs.

X. For every child an education which, through the discovery and development of his individual abilities, prepares him for life; and through training and vocational guidance prepares him for a living which will yield him the maximum of satisfaction.

XI. For every child such teaching and training as will prepare him for successful parenthood, homemaking, and the rights of citizenship; and, for parents, supplementary training to fit them to deal wisely with the problems of parenthood.

XII. For every child education for safety and protection against accidents to which modern conditions subject him—those to which he is directly exposed and those which, through loss or maiming of his parents, affect him indirectly.

XIII. For every child who is blind, deaf, crippled, or otherwise physically handicapped, and for the child who is mentally handicapped, such measures as will early discover and diagnose his handicap, provide care and treatment, and so train him that he may become an asset to society rather than a liability. Expenses of these services should be borne publicly where they cannot be privately met.

XIV. For every child who is in conflict with society the right to be dealt with intelligently as society's charge, not society's outcast; with the home, the school, the church, the court and the institution when needed, shaped to return him whenever possible to the normal stream of life.

XV. For every child the right to grow up in a family with an adequate standard of living and the security of a stable income as the surest safeguard against social handicaps.

XVI. For every child protection against labor that stunts growth, either physical or mental, that limits education, that deprives children of the right of comradeship, of play, and of joy.

XVII. For every rural child as satisfactory schooling and health services as for the city child, and an extension to rural families of social, recreational, and cultural facilities.

XVIII. To supplement the home and the school in the training of youth, and to return to them those interests of which modern life tends to cheat children, every stimulation and encouragement should be given to the extension and development of the voluntary youth organizations.

XIX. To make everywhere available these minimum protections of the health and welfare of children, there should be a district, county, or community organization for health, education, and welfare, with full-time officials, coordinating with a state-wide program which will be responsive to a nation-wide service of general information, statistics, and scientific research. This should include:

(a) Trained, full-time public health officials, with public health nurses, sanitary inspection, and laboratory workers.

(b) Available hospital beds.

(c) Full-time public welfare service for the relief, aid, and guidance of children in special need due to poverty, misfortune, or behavior difficulties, and for the protection of children from abuse, neglect, exploitation, or moral hazard.

For EVERY Child These Rights, Regardless of Race, or Color, or Situation, Wherever He May Live Under the Protection of the American Flag

and other medical scientists should continue, as they will, to push forward so that new knowledge may be secured which will add to the security, improvement, health, and happiness of the future generations of the human race.

Although Dr. Adair stressed in a most striking way our lack of knowledge and our failure to apply intelligently the knowledge we did possess, the fact that maternal deaths in the United States were in excess of those of twenty-five of the largest nations of the world, that many of the causes of this human wastage were preventable by continuous, intelligent supervision from the period of conception on through pregnancy, the delivery and postpartum periods, many remained complacent in the belief that we were adequately protecting the health of our children. Knowledge, however, is useless if not applied. The conference expressed its unanimous opinion that a properly organized follow-up, which would put into action the information that had been assembled, was essential. The members of the large, enthusiastic audience left Washington with the words of the *Children's Charter* ringing in their ears, to await the call which never arrived. Over thirty volumes of collected facts, pointing out ways and means by which the gaps in health protection can be filled have rested on library shelves for over a decade. The Government remained complacent and action was not initiated despite requests by those who had voluntarily contributed so much of their time and efforts to assembling the facts. So the pronouncement of a great national plight produced action and enthusiasm for the Children's Charter, which was strangled and killed by a stone wall of careless indifference.

The League of Nations and Nutrition

In 1915, at a Pan-American Scientific Congress, Prof. Lafayette B. Mendel (15) expressed the opinion that "all the great countries ought to have a central authority, a food commission, which would concern itself exclusively with the far-reaching questions of the well-being of the people." Few people have thought of the League of Nations in con-

nection with food and nutrition. In fact, because of its ineffectiveness in preventing wars, most people have come to regard the League as something of a failure. As a matter of fact, the political activities of the League were only a part of its endeavors; over 60 per cent of its budget was used in technical activities. The Health Organisation of the League carried on one phase of the technical work. This department organized and consolidated shipping regulations to prevent spread of plagues and disease, which eliminated abuses such as burning ships suspected of carrying disease from another port.

The League first turned its attention to food, not as a public health measure, but as an economic measure. It was obvious that a great deal could be accomplished in reducing unrest within nations if some system could be set up whereby the surplus food of one country could be used to alleviate malnutrition in countries which do not produce enough food to meet adequately the needs of their people. Since wheat and wheat products constitute a large percentage of the world's diet, the League's first step was an attempt to regulate the distribution of wheat. Any attempt at regulation, however, was met by antagonism, and at this point the League decided it would be simpler to attack the problem from the direction of consumption. Since each nation is interested in the health and well-being of its people, presumably each nation would be willing to set up nutrition standards for its guidance and education.

When the League met in 1935 a Committee on Nutrition was formed, with 21 members, agriculturists, economists and health experts. The International Labor Office and the International Institute of Agriculture were invited to work in close collaboration. In 1936 the Committee made its first report and in 1937 its final report. This report contained information on every phase of nutrition in relation to agriculture, economics, and health, and included the information on the physiological bases of nutrition, obtained by the Health Organisation. The revelation in 1938–40 that food

surveys (unfortunately not accompanied by clinical observations by qualified physicians) indicated that between one-third and two-thirds of the people of the United States were underfed or misfed sounded another note of warning. Inadequate or improper food with the consequent unsatisfactory nutrition were playing an important role in branding the children of the nation with major physical and mental handicaps.

The Technical Commission of the Health Organisation was asked to define specifically the nutritive needs of human beings from conception to old age. In its report this Commission set up a rational diet and described the needs of different age groups and classes, especially emphasizing the needs of pregnant women, infants and children. Foodstuffs were classified as "energy" foods and "protective" foods. Those in the first group are important for their content of carbohydrates, fats and proteins, which provide calories. The "protective" foods are important because they supply vitamins and minerals. It was pointed out that while people may starve from insufficient calories (energy), people with an adequate supply of energy foods may develop deficiency diseases from insufficient amounts of protective foods (vitamins and minerals). At the time of the Commission's report, advances in food production and distribution had made energy foods available to a great many more people and the threat of famine had been almost eliminated, at least in the western hemisphere. However, the Technical Commission felt that there was widespread malnutrition in the world due to inadequate amounts of protective foods.

At the League's suggestion, many countries set up nutrition committees to advise their governments and educate their people. Representatives of these committees met periodically in Geneva to compare the nutritional state of their nations with the League's standards, to exchange views, make future plans, and coordinate their work. The groundwork laid by the League proved of inestimable value in making the post-war plans of World War II. In the summer

of 1943 a Food Conference in Hot Springs, Virginia, brought delegates from forty-four countries, nine of them occupied by enemy forces, to formulate plans for nutrition after the war. One of the first recommendations of this Conference was to recognize fully and to take full advantage of the recommendations and accomplishments of the League of Nations. At this Conference it was recommended that a permanent United Nations Food and Agriculture Organization be set up. It was recommended that the new organization take advantage of the already existing nutrition agencies set up in the different countries at the suggestion of the League of Nations.

Conference on Children in a Democracy

In 1938 the war mongers were growing more restless and the influence of their machinations was enveloping the United States, the country alleged to be the best fed in the world, strong and invincible. A Conference on Children in a Democracy was called by the Secretary of Labor, the Honorable Frances Perkins—the initial session was held in the White House on April 26, 1939. President Roosevelt said to the group (16):

> Our work will not be concluded at the end of the day—it will only have begun. During the greater part of the coming year the members of this conference, representing every State in the Union and many fields of endeavor, will be at work. We shall be testing our institutions, and our own convictions and attitudes of mind as they affect our actions as parents and as citizens, in terms of their significance to the childhood of our Nation.

Unfortunately, this call came too late to benefit many of the young people who had reached or were approaching military age. Had action been taken during the decade after the 1930 conference it would have been necessary only to recondition the soldiers instead of conditioning them at large government expense. The job of building health, strength, and stamina is best accomplished if the foundation is laid during the formative stages of infancy and childhood. The document of the Conference on Children in a Democracy,

like its companion for the White House Conference on Child Health and Protection, was noble of purpose. It was a call to action: *to do now those things that can be done now and—to plan those that must be left for the morrow.*

Food and Nutrition Board of the National Research Council

Under a charter passed by Congress and approved by President Lincoln in 1863 the National Academy of Sciences since has acted as an official advisor of the government on a wide variety of problems. During the Civil War its committees and members dealt actively with problems similar to those which arose during World War I. The Academy organized the National Research Council in 1916 at the request of President Wilson. In 1918 the President perpetuated the Council by Executive Order 2859:

The National Research Council was organized in 1916 at the request of the President by the National Academy of Sciences, under its congressional charter, as a measure of national preparedness. The work accomplished by the Council in organizing research and in securing cooperation of military and civilian agencies in the solution of military problems demonstrates its capacity for larger service. The National Academy of Sciences is therefore requested to perpetuate the National Research Council, the duties of which shall be as follows:

1. In general, to stimulate research in the mathematical, physical and biological sciences, and in the application of these sciences to engineering, agriculture, medicine and other useful arts, with the object of increasing knowledge, of strengthening the national defense, and of contributing in other ways to the public welfare.

2. To survey the larger possibilities of science, to formulate comprehensive projects of research, and to develop effective means of utilizing the scientific and technical resources of the country for dealing with these projects.

3. To promote cooperation in research, at home and abroad, in order to secure concentration of effort, minimize duplication, and stimulate progress; but in all cooperative undertakings to give encouragement to individual initiative, as fundamentally important to the advancement of science.

4. To serve as a means of bringing American and foreign investigators into active cooperation with the scientific and technical services of the

War and Navy Departments and with those of the civil branches of the Government.

5. To direct the attention of scientific and technical investigators to the present importance of military and industrial problems in connection with the war, and to aid in the solution of these problems by organizing specific researches.

6. To gather and collate scientific and technical information, at home and abroad, in cooperation with governmental and other agencies, and to render such information available to duly accredited persons.

Effective prosecution of the Council's work requires the cordial collaboration of the scientific and technical branches of the Government, both military and civil. To this end representatives of the Government, upon the nomination of the National Academy of Sciences, will be designated by the President as members of the Council, as heretofore, and the heads of the departments immediately concerned will continue to cooperate in every way that may be required.

(Signed) Woodrow Wilson, The White House
May 11, 1918, No. 2859

The National Research Council membership consists of appointed representatives of approximately 85 major scientific and technical societies, representatives of other research organizations and government scientific bureaus and a limited number of members at large—business men interested in engineering and industry. The Council is composed of nine major divisions arranged in two groups. One group comprises seven divisions of science and technology, representing respectively: physics, mathematics and astronomy; engineering and industrial research; chemistry and chemical technology; geology and geography; the medical sciences; biology and agriculture, and anthropology and psychology. The other group comprises two divisions, representing foreign relations and educational relations. With these divisions are associated various technical committees, appointed to supervise projects undertaken by the Council.

The Food and Nutrition Board of the National Research Council, comprising approximately 50 specialists from agriculture, industry and the sciences dealing with food and nutrition, was established in 1940. The members were

chosen from among the foremost men and women in the country, in agriculture, the food processing industry, in food production and distribution, in home economics, dietetics, medicine, nutrition research and public health. Also included are representatives from the United States Government Services and the American Red Cross.

National Nutrition Conference for Defense

The nation was shocked to learn that the children who had been shown to be handicapped in 1930 were still carrying these incapacities when examined as the prospective soldiers of World War II, in 1940. The National Nutrition Conference for Defense (17), called by the President of the United States in May, 1941, brought together much of the evidence. At this meeting, General Hershey announced that the first million physical examinations conducted under Selective Service resulted in approximately 133,000 rejections as unfit for military service *from disabilities directly or indirectly connected with nutrition.* Nutritional deficiencies, directly or indirectly, had disqualified for military service about one man in seven. The recommendations of the Conference included a thorough summary of the situation and established a sound basis for a national nutrition program which would serve during the war emergency and in the peace:

> As a result of its deliberations, the National Nutrition Conference makes the following recommendations to the President. During the sessions of the Conference, a state of Unlimited National Emergency was proclaimed by the President. The Conference feels that this gives added significance to its recommendations, and we pledge our full support to the President in mobilizing our national resources to meet this emergency.
>
> I. The great and sometimes startling advances in our knowledge of nutrition in recent years have made it clear that the food an individual eats fundamentally affects his health, strength, stamina, nervous condition, morale, and mental functioning. It is of paramount importance to the normal growth, development, and health of children. In view of these proven facts, it is vital for the United States to make immediate and full use of the newer knowledge of nutrition in the present National Emergency. To neglect this aspect of defense would be as hazardous as to neglect military preparedness.

II. The newer knowledge of nutrition should be used not only for the benefit of our armed forces, who must of course be adequately fed, but for that of all workers in industries directly and indirectly related to defense, and also for the civilian population as a whole. Wars are won or lost according to the health, courage, and morale of whole populations and their ability to exert themselves to the utmost, and this is particularly true in modern total warfare. The food provided for women and children is as important to the future of the Nation as that provided for defense workers.

III. Recent dietary studies among large groups representative of the people of the United States, clinical studies among smaller groups, and the examination of men called up for military service show clearly that poor diets and malnourishment are widespread in this country. While the conditions revealed offer no ground for alarmist statements, they are serious enough to be a genuine cause of weakness in the present National Emergency and to warrant national attention and concerted action. A widespread disease epidemic would receive such attention immediately. Malnourishment is more insidious and less immediately obvious in its effects, but it is no less harmful when all the results are considered.

IV. Few problems in the field of public health are simple and that of malnourishment is particularly complex. It has not only medical but social, economic, and psychological aspects. To attack it on a national scale will require peculiarly widespread and wholehearted cooperation on the part of all elements in our population. This Conference urges the following lines of attack as particularly important:

A. The use of the allowances of calories, protein, and certain important minerals and vitamins, recommended by the Committee on Food and Nutrition of the National Research Council, both as the general goal for good nutrition in the United States and as a yardstick by which to measure progress toward that goal. It should be clearly recognized that these recommended allowances represent the best knowledge now available, and that they will undoubtedly be modified as more knowledge accumulates.

B. Translation of these allowances, and other similar technical material, into terms of everyday foods and appetizing meals suitable for families and individuals at different economic levels, in such a way that the newer knowledge of nutrition can be applied simply and practically in every home and in accordance with the food preferences of the family.

C. Vigorous and continuous research to add to our present knowledge of the nutritional needs of individuals, the nutritional status of groups in the population, the nutritive content of everyday foods,

and the effects of various methods of production, processing, storing, and cooking on their nutritive value.

D. More widespread education of doctors, dentists, teachers, social service workers, public health nurses, and other professional workers in the newer knowledge of nutrition. At present this knowledge, especially in its practical applications, is familiar to far too small a group even in the professional fields.

E. Mobilization of every educational method to spread the newer knowledge of nutrition among laymen by means of the schools, motion pictures, the radio, the public press, home and community demonstrations, and all other suitable means.

F. Mobilization of all neighborhood, community, State and national organizations and services that can contribute in any way to raising the nutritional level of the people of the United States. Many existing organizations are available for this purpose. How they can be mobilized to cooperate most effectively will depend on local situations. State nutrition committees can give especially useful assistance in organizing this effort.

G. Vigorous and continued attack on the fundamental problems of unemployment, insecure employment, and incomes inadequate to maintain an American standard of living. It is common knowledge that malnourishment and ignorance are frequently twins born of the same mother—poverty. The newer knowledge of nutrition should be a powerful stimulus to greater effort to alleviate and eventually eliminate poverty.

H. Full use of any practical devices, such as the Food Stamp Plan, school lunches, and low-cost milk distribution, which will bring nourishing, adequate meals to those who could not otherwise afford them, and at the same time help to distribute food surpluses at a fair return to the farmer.

I. Efforts to improve food distribution, including processing, marketing, packaging, and labeling, to bring about greater real economies for the consumer. These efforts would include vigorous prosecution of illegal practices under the antitrust laws and the laws relating to unfair trade practices wherever such practices result in unjustifiable increases in food prices.

J. Encouragement in all practical ways of greater production of the foods needed in more abundance in the average American diet. These foods include milk and milk products, eggs, vegetables, fruits, and, in the case of many families, lean meats, and sea food. Much can be accomplished also by making more use of low-cost foods of high nutritive value such as soy-bean flour, peanut flour, and dried skim milk.

K. Encouragement in all practical ways of more production for home use by rural people, especially those at low-income levels. Large numbers of farm families can greatly improve their nutritional status by making more complete use of the resources of their own farms.

L. Improving the nutritive value of certain low-cost staple food products, such as flour and bread, by enrichment with nutritive elements that have been removed from them in modern milling and refining processes. Pending further developments in the milling of grain so as to retain their full, natural, nutritive values, enrichment is an economical way to improve American dietaries almost universally, without interfering with deeply ingrained food habits. The method, however, should be used with discretion and only on the basis of findings of medical and nutritional experts.

V. These broad recommendations are made as the basis for a national nutrition policy and an action program that can reach every community, and if possible every individual, in the present emergency. The Conference also wishes to record its belief that such a policy and program have implications that go beyond the present emergency.

There seems no reason to doubt, on the basis of present evidence, that just as, by the use of modern medical science, we have conquered diseases that took an enormous toll of life in the past, so by the use of the modern knowledge of nutrition we can build a better and a stronger race, with greater average resistance to disease, greater average length of life and greater average mental powers.

This can be done by the conquest of hunger—not only the obvious hunger man has always known, but the hidden hunger revealed by the modern knowledge of nutrition.

The United States is probably the best fed Nation in the world today, but we cannot afford to judge ourselves by external standards. We should judge ourselves by the standard of our own potentialities—our resources in food, in technical developments, in scientific knowledge. By that standard, we fall far short of our goal.

No nation, certainly no large nation, has ever truly conquered hunger, the oldest enemy of man. Such an aim is not too high, such a goal is not too difficult, for the people of the United States. It is in line with our tradition of pioneering on new frontiers. It is a particularly fitting task for us in this day when democracy should point the way to a new and better civilization for oppressed peoples all over the earth.

A few months later Ciocco, Klein and Palmer (18) compared the physical status of selectee candidates upon examina-

tion in 1941 with their physical status 15 years earlier, when the men were school children. For these studies the records of 411 registrants were available. In this group the total number of rejections (classification in I-B or IV-F) and the distribution of the causes for rejection were comparable to the figures for the entire country. A large percentage of the rejections were found to be for conditions which had been noted on the examinations 15 years earlier.

It is very likely that a percentage of such disabilities from unsatisfactory nutrition have their incipiency in poor prenatal nutrition. If this is true, then it behooves the American people to make every effort to augment the nutritional heritage of the next generation by enhancing the nutritional background under which the child is conceived, then grows. Adair (19) believes maternity is the frontier of human welfare and has stated that

> . . . hereditary and environmental influences of maternity determine very largely the future individual. They also decide to a large degree the future of the race and of mankind. . . . Much has already been done to prevent illness and to protect the mother and the infant; many individual problems have been solved; illness and death have been reduced. But much more is required on the positive side. We have not done enough to promote the health of the individual. Certainly far too little has been done toward the solution of the problems surrounding maternity as a part of human welfare. The frontiers have been only partially crossed and our ignorance, intolerance, and inhumanity still hold us back. We are ignorant of many things which the future will reveal. We are intolerant of new ideas and new ideals and withal we are inhuman in a negative sense if not positively so.

Even slow progress in the direction of improving nutrition during the reproductive cycle would represent an incalculable gain to the nation, in lowered mortality, lower incidence of endemic and epidemic diseases and fewer minor illnesses; all of these with consequent reductions in the cost of medical care and in time lost from gainful activity. Following the White House Conference (1930) some private groups started notable studies which today are yielding fundamental facts; others, in the medical profession, have

worked to bring greater protection to mothers and were responsible for the formulation of the Mothers' Charter.

The Mothers' Charter

THE DEFENSE OF MOTHERS IS THE DEFENSE OF NATIONS

Every potential mother envisions the pleasures and obligations of creating and sustaining new life and is entitled to health and protection for the benefit of herself and humanity and should have:

1. The inherent right to be well born without inherited or transmitted defect or disease.
2. The inalienable right to protection from disease and harmful influences during early infancy, infancy, and childhood, and to full development.
3. The opportunity to learn and know herself during adolescence and maturity and to acquire a knowledge of the origin and significance of human life.
4. The right to protection from pitfalls of married life and to a knowledge of its significance to herself and her potential family.
5. The privilege of proper premarital and preconceptional medical examination and advice and care for herself and her mate.
6. The right of proper and adequate care during pregnancy.
7. The right to receive adequate and necessary care during labor in her home or hospital.
8. The right to have appropriate care following labor in her home or hospital.
9. The right to secure proper and continuing subsequent care for herself and baby.
10. The right of preservation of health and life and happiness for herself and family.

Approved by the American Committee on Maternal Welfare, June 4, 1941.

Sufficient experimental data have been accumulated to indicate that the well being of the unborn child and the outcome of childbearing are influenced by the mother's nutritional state before and at the time of conception and by the adequacy of her diet during pregnancy. Not infrequently malnutrition is produced by pregnancy. The late Dr. Joseph B. DeLee, famed for his outstanding work in obstetrics at the Chicago Lying-In Hospital, years ago

pointed out that childbearing possesses many of the organic and psychic symptoms characteristic of illness and may bring disability in varying degree to the mother. Like sickness, it often results in permanent maternal body damage or impairment of function, and sometimes death. Evidence indicates that if the mother were in a nutritionally adequate condition prior to conception and received an adequate diet during pregnancy and lactation, supported by sound medical guidance throughout, maternity would be less hazardous and children would be more apt to receive their rightful nutritional heritage.

Contrary to usual obstetric teaching, the adequacy of the mother's diet during pregnancy has a direct effect on the physical condition of the infant, according to the evidence presented by Dr. Harold C. Stuart (20) in one of many reports from the twelve-year research program on the growth and development of the well child initiated by the Department of Child Hygiene, Harvard School of Public Health. As an approach toward solving the problem of the extent of the dependence of the unborn child upon the maternal diet, Stuart and his associates studied the diets of 216 women in relation to the physical condition of their infants, the course of pregnancy with regard to pre-eclampsia, duration and character of labor and type of delivery, and the complications of the post-partum period. Forty per cent of the women studied had eaten poor diets during pregnancy. The relationship between the adequacy of the mother's diet and the condition of the infant was found to be more marked than that between the diet and the course of pregnancy. The indications were that with an inadequate prenatal diet the infant suffers to a greater degree than the mother. In the 216 cases studied, every still-born infant, every infant who died within a few days of birth (with one exception), the majority of the infants with marked congenital defects, all prematures, and all "functionally immature" infants were born to mothers whose diets during pregnancy were very inadequate. No mother whose diet during pregnancy was

considered good or excellent had eclampsia (convulsions), while with a "poor to very poor" diet during pregnancy almost 50 per cent had pre-eclampsia. There was a tendency for the mothers whose diet during pregnancy was poor to have more difficult types of delivery and have more major complications at delivery, despite the fact that these women had, on the average, smaller infants than were born to the women whose diets were good or excellent.

The questionable procedure of attempting to reduce the weight of the baby by restricting maternal diet in order to facilitate ease of delivery, has enjoyed some popularity in certain localities. Untutored and indiscriminate manipulation of the maternal diet is hazardous to both mother and child. The period of prenatal life is the period of actual formation of most of the adult structures; adverse environment during this formative period may have serious consequences. Many recent studies on animals—the most dramatic were conducted by Dr. Josef Warkany of the University of Cincinnati (21)—have shown that rats born of animals on a grossly deficient diet usually have deformities of the long bones, sternum (breast bone) or mandible (jaw).

Dr. Lester W. Sontag, director of the Samuel S. Fels Research Institute, Antioch College, has devoted more than a decade to the study of human maternal-fetal relationships from the standpoint of how fetal development may be influenced by varying maternal factors, as determined by medical, physiologic, biochemical and psychologic observations. Again in conformance with the findings of the White House Conference on Child Health and Protection, his many consecutive and diversified observations on women during pregnancy, at delivery, and during the nursing period, together with periodic studies on the child from birth to maturity have lead him to state (22) it is possible that

. . . the physical stamina or constitutional adequacy of a newborn infant may depend to some degree upon the adequacy of its mother's diet and her body stores of certain of the vitamins and amino acids. Roentgen examination of a group of newborn infants has shown that the severity of

roundbone scars resulting from the birth process is very much greater in those children born of mothers whose diet was *grossly* defective in the muscle-and-gland-building elements and in vitamins. This fact suggests that children from inadequately nourished mothers may suffer a greater neonatal growth interruption than will those of well-nourished mothers.

* * *

The evidence available in the literature from both animal experimentation and the observation of pregnant women and the children they bear are indications that differences in environment during the fetal period may be of great importance in the development of the child both before and after birth. Such factors as the drugs women use during pregnancy, their nutrition, endocrine status, emotional life and activity level during gestation may contribute to the shaping of physical status, behavior patterns, and postnatal progress of children they bear.

Dietary studies supplemented by clinical observations on the mother during pregnancy and a follow-up on the infant indicate a relationship of the prenatal diet of the mother with the incidence of breast feeding, as well as with the development of the infant. Drs. J. H. Ebbs and Frederick F. Tisdall of the Departments of Obstetrics and Paediatrics, University of Toronto, conducted notable studies at the Toronto General Hospital on the relation of maternal diet to breast feeding (23). They took expectant mothers attending the prenatal clinic and studied their food intakes for one week. The dietaries were evaluated and three groups of patients were formed. In one group 120 women were left on their poor diets throughout pregnancy; in another group 90 women who were found to have poor diets were given supplemental food from the fourth or fifth month of pregnancy until the baby was six weeks' old; in the third group 170 women were given advice and the diets improved by education, thus forming a good diet group.

During the course of pregnancy the mothers on a good or supplemented diet enjoyed better health, had fewer complications and proved to be better obstetrical risks than those left on poor prenatal diets. The incidence of miscarriages, premature births and still births in the group on poor diets

was much greater. The incidence of mastitis (breast inflammation) was twice as great in the poor diet group as in the supplemented group.

The frequency of illnesses in babies under the age of 6 months and the number of deaths resulting from them were many times greater in the poor diet group. The Toronto physicians observed that when the diet was changed from a very poor one by adding extra foods in quantities sufficient to furnish dietary essentials to satisfy normal requirements, the women not only improved physically, but also mentally. Their attitude towards the outcome of the pregnancy, which formerly was one of apathy, soon became one of normal interest. The cost of the food supplied "for an average period of 4.7 months was $25.00 per patient." This is an insignificant price to pay for healthier pregnant women, healthier babies, reduced suffering during childbirth and better post-delivery health for both mother and child.

Although recognizing that there are other important factors in the successful outcome of pregnancy, Ebbs and Tisdall interpret the results of the study as indicating that the nutrition of the mother during the prenatal period influences to a considerable degree the whole course of pregnancy, and in addition directly affects the health of the child during the first six months of life. Moreover, the members of the group which was supplied with extra food and of the group which was educated in providing a good prenatal diet were more successful in nursing their infants than the mothers who had been left on poor prenatal diets. The effect of postnatal diet upon nursing was evidenced by a decrease in the percentage of breast fed babies when the food supplement was stopped six weeks after the birth of the baby.

In England, in ten classes of the population, the greatest decline in breast feeding occurred in the first month, among the wives of laborers. Continued poverty lowered the ability of the mother to keep the baby on the breast through the first month and the lowest incidence of breast feeding occurred in depressed industrial areas. It is well recognized

that poor diets go hand-in-hand with poverty, which results in weakness and unsatisfactory health.

Dramatic as the results of these survey studies on human mothers have been, more exact chemical and physiological studies have yielded striking results. The period of pregnancy is one of great stress and physiologic readjustment, owing, at the onset, to the necessary accommodation by the glands of internal secretion to the new and diverse demands created by conception. During the lying-in period and lactation, likewise there are extensive physiologic readjustments and if the maternal organism is poorly nourished, because of insufficient food, the wrong kind of food, interference with food utilization, or disease, its nutritional requirements may be altered. Certain diseases may be accompanied by malnutrition and both conditions benefited by the administration of the food mixture best suited to that individual, at that time. Women who work in factories, where cafeteria or restaurant facilities are inadequate, who are unable to purchase the proper foods because of working hours, or who have acquired the habit of not eating breakfast, or a light one, may be either undernourished or malnourished in varying degrees.

In summarizing the nutrition problems in pregnancy and lactation, Ebbs (24) says:

> The ideal normal nutritional state for pregnancy would be one in which the maternal body was endowed with the proper nutritional elements before, during and after the pregnancy, to ensure the optimum needs of the fetus in its intrauterine development, to supply stores for its needs in early infancy, to ensure adequate nutrition for the normal physiologic requirements of the mother, and for added requirements resulting from pregnancy and lactation. It is therefore not enough to discuss the question of diet for the expectant mother by simply saying that her needs are those of any healthy woman. While we have been accustomed to thinking of the fetus as parasitic and therefore obtaining its nutritional needs even at the expense of the maternal stores, perhaps we should consider more optimum development of the fetus by making all needs readily available. Gross nutritional deficiencies are seldom encountered in the

population today, but, as our knowledge of nutrition increases, more and more evidence is presented that there are minor deficiencies which impair to varying degrees the health and efficiency of our population. Such minor or subclinical deficiencies, which in the average individual would take weeks or months to develop, could be exaggerated and hastened by the increased nutritional needs during pregnancy.

Chapter Three

CHOOSING AND USING NUTRIMENTS

Food consumption is intimately entangled with human conduct, personal likes and dislikes, racial and religious customs, as well as with economics, production, distribution and availability of foods. We were stirred to action by the war emergency and shortages and rationing impressed people with the importance of food. It came as a great shock to the nation to learn that two-thirds of the people in the United States are not getting the food that science indicates is necessary for buoyant health and nutritional stability. This, coupled with the fact that so large a percentage of our manpower available for military services has been found wanting because of direct or indirect influence of undernutrition or malnutrition, has stirred us from our lethargy and indifference towards food and health into action. There is a growing interest in food, its significance in health, efficiency, happiness, reproduction and longevity.

Changing Food Customs

To one who has given little thought to the subject, the dietary habits of a community or a nation may appear as something more or less fixed from generation to generation. This is not a correct point of view. Adequate nutrition may be exemplified alike among the meat eating Eskimos and the vegetarian Hindus. Where the dietary instincts and the availability of foods have led mankind to adopt a more diversified mixed ration, one may discover shifts of custom and changes in eating habits within comparatively short periods of time. W. R. Woolrich (25) points out that since 1900 several forces have been at work to make effective changes in these habits.

Prior to 1900 the nation was dependent upon a network

of railroads to move foods and materials of all kinds. Since that time, engineering developments have brought to the American people (1) interconnected communication and electricity systems for all America; (2) mass production of the automobile and truck; (3) construction of a network of all-year highways to virtually every rural and urban door of the nation.

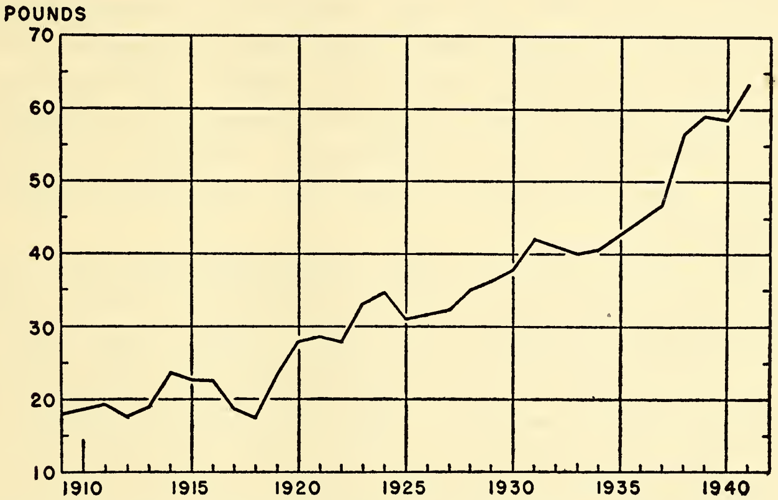


FIG. 3. Per capita consumption of citrus fruits in the United States, 1909–1941 (75).

In the United States the shifts of food customs have been diverse and far-reaching. The ever-increasing consumption of citrus fruits (Figure 3), tomato and vegetables has been a great force toward the improvement of nutrition (75). The desirable food habit of starting breakfast with orange or tomato juice and the use of more fruits and vegetables have been adopted with great rapidity. According to Dr. John M. Cassels, head of the Requirements and Allocations Branch of the Food Distribution Administration (26), over the consumption level in 1909, the estimated per capita consumption in 1941: of citrus fruits had been 3 times; of canned fruits and vegetables 2.4 times; of evaporated milk, cheese and ice cream, 2.5 times; of fresh vegetables 1.4 times.

Other shifts in dietary customs have not been so desirable. The trend towards the use of more highly refined foods has

not been a healthy one. The white patent flour and bread and white rice, though they are good to look at and have an appetite appeal, have not the nutritive value of the original cereal or the less highly milled grain. The increased consumption of sugar has been unfortunate. Considerable evidence is amassing which indicates that high sugar consumption is accompanied by increased dental caries. Much evidence shows that the trend toward the consumption of refined foods is a nutritional disadvantage. Perverted tastes and appetites develop and health suffers. Natural foods carry many known and undoubtedly some unknown nutriments which are lost in processing. Satisfying a "sweet tooth" may crowd out of the day's diet many essential nutriments.

Our tastes have changed. Bleaching vegetables has stripped natural products of certain nutritive qualities while catering to the demands of the people. Again, white cabbage has greater appeal to most people than green, though the latter is richer in vitamins. Bleached celery is preferred to the unbleached; and head lettuce to the green leaf lettuce. Dr. Margaret Mead, secretary of the Committee on Food Habits of the National Research Council, has emphasized that the establishment of sound nutrition habits implies some knowledge of the psychology of eating, of anthropology and religion, sociology and economics, and believes that it is only when these items are given their proper weight that the findings of the science of nutrition can be brought to play upon our subject, man, with any modicum of expectation of success.

Mark Graubard (27) in discussing *Man's Food: Its Rhyme or Reason* states: ". . . Food with man is not just food. It is the crossroads of emotion, religion, tradition and habit. That to which we are accustomed seems natural, while the strange seems unnatural and undesirable."

We are familiar with the regional or provincial dietary habits demonstrated by the Boston baked beans and cod fish cakes of New England and the salt pok, corrn bread and

molasses of the South. Beyond these local considerations, man's attitude toward food may be accompanied by other dietary notions and emotional attitudes. Almost every type of food has been singled out for discrimination by some group or individual at some time or other. These prohibitions are seldom related to welfare or economic motivations, but rather are based upon beliefs maintained at the time and may vary with the culture.

Food plays a role in almost every culture. The manner of eating varies widely and the kinds of food served "for company" varies, for it is greatly influenced by prestige. One group may scorn baked ham for a company dinner and consider it necessary to serve steak or chicken for social prestige. And at the dinner party the wife may talk volubly about the food likes and dislikes of the children or the husband, just as an outlet for her own pent up feelings. So it is that food which is essential to man's very existence is so uppermost in his mind that it plays an important role in his religion, social conduct, courtship, loyalties and fears.

Once food habits are formed, changes are laborious. If food habits could be changed readily and all the newer knowledge of nutrition could be generally applied, the health of the nation would be greatly improved. Nationwide application of a rationing and food subsidy plan designed to apply the modern pattern of nutrition greatly improved the health of the people in Great Britain, even under the constant strain of war and the curtailment of food supplies. Although their diet, of necessity, was monotonous it carried the essential nutriments in sufficient quantities to meet minimal nutritional requirements. There are many indications that the health of the people in our own country was improved during the war, partly because people had more money to spend on food but also because rationing made for more adequate distribution.

Since its organization in 1940, the Committee on Food Habits of the National Research Council has been concentrating its efforts, first, on the diffusion of knowledge and the

improvement of food habits; second, on the analysis and interpretation of existing knowledge upon the methods and principles of the many disciplines that might be applied specifically to the field of food habits, third, on the establishment of research projects which will furnish information upon methods and principles applicable to the field of food habits. The Committee states (28) that:

> To be successful, the nutrition educational campaign must achieve the following: (a) create interest in nutrition; (b) educate people to know and wish the necessary changes in their diet; (c) produce these changes and establish them as habits; (d) firmly establish these adequate habits in the culture as food folkways.

Man's worst enemy is man himself, his nature, his habits, his beliefs and practices. Because of certain psychological states of man he may not yield readily to changes, especially to foods. Indeed, he may even have an aversion to the foods that science has demonstrated are necessary for buoyant health. He may choose to follow his taste and socalled instinct, a course which may be not only disadvantageous, but even harmful to him.

Now if we are to change our eating habits in accordance with a pattern dictated by science to give mankind the optimum of health, false and harmful exaggerations must be guarded against. Students of nutrition have seen the dramatic effects of food on the health and well-being of animals and man. With deficient diets, symptoms of malnutrition occur within a few weeks. Dramatic recoveries occur within a few days after the missing nutriment(s) is added to the diet. Thus, disfiguring and fatal diseases such as beriberi, scurvy, pellagra and rickets have been demonstrated beyond a shadow of doubt to be due to the lack of food components, minute in quantity but without which the body cannot function properly. There are many dramatic stories of human beings who have been warped in mind and body through the lack of the right kind of food. Even the most ardent skeptic of the effective role of foods in their life-giving qualities could hardly retain his skepticism after

reading dramatic accounts of observations made by great scientists, such as the one of Dr. R. R. Williams recorded by Graubard (27):

> On several occasions in the absence of a medical associate, I went at the call of a public health inspector to the Tond slum district of Manila to attend without benefit of medical certificate reported cases of beriberi. Often I dosed the baby myself to be sure to get as much of my precious preparation inside and as little outside as possible, and sometimes sat down beside the anxious mother on the split bamboo floor of the little nipa shack to await results. Within as little as three hours I have seen the cessation of the weird, almost soundless crying which, due probably to paralysis of the larynx, is characteristic of the last stage of the malady. Easing of the gasping breathing soon followed, and then occurred the smoothing of the wild pulse, the fading of blue lips, a hungry nursing, and peaceful sleep.

The stories of scourges of scurvy, beriberi, pellagra, xerophthalmia and rickets, of their prevention and cures, are legion and similarly dramatic. But in spite of the many convincing demonstrations, some people maintain a state of skepticism and persist in their slavery to habit, complacency, rationalization and beliefs.

While the achievements in nutrition have been most gratifying and their influence upon the improvement of the health of mankind have been demonstrated to be real and far-reaching, much remains to be accomplished in the future. The story of food in action is only in its initial stage of development. The extension of knowledge and the application of the science of nutrition will extend our mastery over further ills that beset mankind. The knowledge gained thus far has become widely diffused throughout our population and has affected their dietaries.

The highly publicized knowledge that the vitamins do play an important role in normal health and vigor and that the response of deficient individuals to specific nutriments may at times appear almost magical, has led to exaggerated claims and much misuse. Indeed, it has led to shotgun vitamin administration, over-emphasis on the vitamins and disregard of other nutriments equally essential in the com-

plete diet. The vitamins make up only a small fraction of the number of nutriments necessary for optimal health, representing only about one-fifth of the essential components of a complete diet. (Over-emphasis of the vitamins on the radio and the flamboyant advertising of such items as vitaminized cold cream as tissue food and vitamin mixtures to cure every ache and pain described in the medical dictionary, have resulted in the spread of misinformation and produced condemnation.) Drs. Eugene F. Du Bois and William H. Chambers (29) of Cornell Medical School have voiced the antagonism that many feel:

> Calories in medical practice are just as important as they ever were, in spite of the fact that attention has been centered on the vitamins. No supplements of vitamins and mineral elements can alter the laws of the conservation of energy. Calories are still needed to keep the body warm and to furnish energy for muscular work.

In 1938 the American public spent 100 million dollars for vitamin preparations and the sales are still increasing. Fortunately, there are relatively few incidents of harm from overdosage, but it is an extremely great economic waste. Restricted diets may lack some of the vitamins and the sick and diseased individual may need additional vitamins beyond amounts provided by an adequate diet. The Journal of the American Medical Association has declared editorially (30), and nutrition scientists agree that

> . . . all the substances required by normal adult human beings can be supplied under ordinary conditions by a balanced diet.
>
> The body of man has not evolved so that he can function efficiently on tablets and food concentrates. His physiology requires the materials essential to health and well-being in the form of food. Synthetic tablets are not a perfect substitute. Foods common to the American dietary properly selected will contribute everything that foods can give to the maintenance of good health. From an economic point of view, foods are the cheapest source of vitamins and other essential elements. The ingredients of food purchased in the form of pills are wastefully expensive. In these times, when conservation of economic resources is essential, people should remember this important fact. But they must also realize that, in the treatment of disease, often tablets are advantageous in place of food.

. . . a given amount of vitamins, like oil in the crank case of a car, is necessary to insure proper functioning; but the efficiency of the parts is not increased by adding unlimited amounts.

Food Fads and Fashions

Since there is such an intimate and vital relationship between food and our daily lives it is not surprising that dietetics has proven such a fertile pasture for cultivation by the sciosophist. The late David Starr Jordan (31), eminent biologist and educator, coined the term *sciosophy* to describe systematized ignorance, "the most delightful science in the world, because it is acquired without labor or pains and keeps the mind from melancholy."

The mysteries of vitamins and enzymes, the specific effects of minerals, the disparity among proteins, the shortcomings of calories and the complexities of biological acid-base equilibria—all of these offer opportunities for sciosophical interpretations which seem gospel to the man in the street; and if they extract money from him, all the better. Dr. Morris Fishbein, editor of the Journal of the American Medical Association, has said that there is a sucker born every minute and a quack every hour to take care of the sixty suckers and that, whereas the old patent medicine quack reached 10,000, the modern food quack, using high-pressure methods, reaches 100,000. Of all quacks, or sciosophists, the food faddist gets the largest following and a highly lucrative business. Recently, one of the so-called "food scientists" was making such statements as: "fear of the dark, nail biting, and gossiping are produced by a lack of calcium," and, "You will get more out of your food if you chew it for half an hour."

The idea that one can get more out of his food and thus eat less, through the simple process of thorough mastication, is one of the more ancient food fads. One of the most obvious sciosophies, it apparently is an old standby which the food cultists resurrect every time there is danger of a food shortage. Another ancient, apparently honorable, food fashion is vegetarianism. The catch in this particular cult

is less obvious, perhaps, but nonetheless evident. These so-called vegetarians are, in most instances, vegetarians in name only and are more properly designated as lacto-ovo-vegetarians, since usually they include in their diet two of our most important and nutritious animal foods, milk and eggs.

The high degree of commercialism and the specialized techniques of advertising developed in this country have made of it a Mecca for dietary fashions. In one group are those who sponsor the "eat more" slogans and have a special food to sell; in the other are those who foster and instill the belief that improper food combinations will develop explosive mixtures or mysterious toxins in the alimentary canal. Many of the protagonists of the first group are paid to create a greater demand for individual foods or food products, and characteristically they promulgate some one thing as a panacea for any and all ills. Certain individuals undoubtedly benefit from taking bran or yeast but for others excessive amounts of these foods may be injurious. The prescription should be written for the individual, by a competent physician and not by the manufacturer through his advertising agency. Women with ample figures and finances are particularly susceptible to the vendors of "slenderizing victuals."

The food cultists of the "dangerous combination" group attempt to frighten by expounding the theory that certain foods are individually harmless, but in combination with other foods they react chemically to form toxins which poison the whole body. For a price, these sciosophists guarantee to furnish a long list of proper and safe food combinations. Typical tripe from this type of food quack is: "The heavy user of starches or sugars, if he combines these with either acid fruits or with meat or eggs, can get up a very sizeable jag from the alcohol generated in stomach and intestine." A large portion of our population daily consumes meat and potatoes without developing any "misery of the stomach." Such sciosophical taboos as acid fruits with milk, lobster with ice cream, and tea with salmon are

products of the lurid imagination of food faddists, without scientific basis whatever for these myths. A few individuals have real food idiosyncrasies. They have become sensitized to the protein in a certain food and whenever it is eaten develop a definite allergic reaction. In such cases, the advice of a physician specializing in allergy, not that of a food quack, should be sought.

Food faddists take pleasure in denying themselves the more appetizing, and in many instances, the more nutritious foods. Actual perversion of appetite may result from advocating a special healthfulness for particular foods, such as fruits or nuts, and subsequently restricting the food supply to a few nutritionally incomplete articles. It has been pointed out (32) that "hunger may be sufficiently insistent to force the taking of food which is so distasteful that it not only fails to rouse appetite, but may even produce nausea." On the other hand, we indulge in a tasty dessert after hunger and the food requirements of the body have been satisfied. Prof. E. V. McCollum (33) said: "Throughout history, appetite has been an antagonist to be fought against and conquered. The debilitated banqueter has often been the preacher of the virtues of abstemiousness, as others who have sown 'wild oats' have been the champions of moderation and grace."

The pressing problem today, in combating food fads and fashions and the quacking sciosophists who prey on the innocent and gullible alike, is to convince the general public that there is a real scientific basis for competent dietary advice and to induce them to give up eating according to inherited or acquired tastes, appetites and prejudices. No single food is perfect and wise eating consists of selecting foods from as great a variety as possible and eating enough but not too much.

Hunger

Everyone has experienced the uncomfortable, gnawing sensation of an empty stomach. It is the commanding signal

which calls to consciousness the idea of food and ceases when it is heeded. Agony from hunger drives to action, it breaks a courageous spirit, vitality ebbs, energy flags, morale and efficiency decrease. Dr. Walter B. Cannon (32) states that hunger "is a sensation so peremptory, so disagreeable, so tormenting, that men have committed crimes in order to assuage it. It has led to cannibalism, even among the civilized. It has resulted in suicide. And it has defeated armies—for the aggressive spirit becomes detached from larger loyalties and turns personal and selfish as hunger pangs increase in vigor and insistence." Hunger pains are caused by fairly frequent and rhythmic contractions of the empty stomach. In 1911, Cannon demonstrated that the powerful contractions of the empty stomach occur at average intervals of sixty seconds and last approximately thirty seconds. These results were confirmed by the experimental physiologist, Dr. Anton J. Carlson of the University of Chicago. In *The Control of Hunger in Health and Disease* (34) he describes experimental work showing that hunger may initiate an occasional weak contraction of the empty stomach which may gradually become more vigorous and may occur at shorter intervals, consummating in a true spasm of the gastric muscle. Hunger is associated with either the contractions or spasms, or with the dull, aching or gnawing pain in the lower midchest region and in the "pit of the stomach."

The empty stomach passes from the hyperactive stage to a period of relaxation and remains inactive until another cycle of activity emerges. Carlson observed that the hunger contractions follow one another for a period of about thirty minutes. Then, for a period of one-half to two hours all contractions stop, after which a new period of activity sets in. These active periods are called hunger periods. If fasting is prolonged, the periodic activity continues. The hunger periods are not essentially different, or longer in duration after a ten-day fast than after an all-night fast, broken by breakfast. In this sense, hunger does not increase in intensity as fasting is prolonged.

The rhythm of these waves, however, varies among individuals in accordance with the emptying time of their stomachs. Some infants, for example, need to be fed every two to three hours to stop the goading of hunger pangs, while others who possess stomachs with longer emptying times may be sustained comfortably by feeding intervals of four hours or more. Some adults eat two or three meals per day without distress while others must have small quantities of food at more frequent intervals in order to avoid the hunger sensation. The stomach may be conditioned by habitual regularity in eating intervals and by the quantity and kind of foods eaten. These patterns may be of environmental origin, or influenced by climatic conditions.

Appetite

Like hunger, the sensations of appetite are complex. As a matter of fact, hunger and appetite are so intimately interrelated that a discussion of one is incomplete without consideration of the other, although the two experiences are fundamentally different. Cannon (32) states:

> The view has been propounded that appetite is the first degree of hunger, the mild and pleasant stage, agreeable in character; and that hunger itself is a more advanced condition, disagreeable and even painful—the unpleasant result of not satisfying the appetite.

Studies on man and animals have given us a scientific basis for the conclusion that there is a selective mechanism which controls eating, which functions through appetite or the desire for food. We do not understand the physiologic reaction back of this mechanism. We know little more today than did Osborne and Mendel, in 1918, when they stressed that the desire of a young animal for food is something more than a demand for calories and that the demand made by the growth impulse must also be met by a food with the proper chemical constitution (35).

Careful observations show that appetite encompasses psychic factors. Cannon's observations (32) indicate that

appetite is related to previous sensations of taste and smell of food—delightful and disgusting tastes and odors, associated with specific edible substances, determine appetite.

> Thus, by taking thought, we can anticipate the odor of a delicious beefsteak or the taste of peaches and cream, and in that imagination we can find pleasure. In the realization, direct effects in the senses of taste and smell give still further delight. . . . Observations on experimental animals and on human beings have shown that the pleasures of both anticipation and realization by stimulating the flow of saliva and gastric juice, play a highly significant role in the initiation of digestive processes.

The desire for food, or appetite, and sensations of hunger are signals which maintain the bodily supply of nutriments, and operate for the welfare of the individual and the race. Dr. C. Anderson Aldrich and Mary M. Aldrich (36) speak of the appetite and hunger regulating mechanism as the "stop and go" feature indispensable for race survival. The hunger pain develops to give us a reliable impulse for beginning our meals and the inner feeling of satisfaction, or satiety, tells us when to stop.

Hunger is usually accompanied by appetite, but one may have appetite without hunger. An attractive, tasty meal may arouse the desire to eat even after all hunger has been appeased—we continue to eat because of the acquired liking for certain foods and of the memory of pleasant experience with food. On the other hand the hunger mechanism appears to be inherited and is not essentially modified by experience of the individual. Dr. and Mrs. Aldrich have made the interesting observation that the mechanism by which we eat is an infinitely more efficient and delicately adjusted engine than any devised by man. And if hunger may be called the self-starter of this machine, appetite is the carburetor and controls the mixture and amount of fuel. Both are necessary and must operate together, or before long the motor back-fires.

As long as man was a food gatherer and not a food producer, he killed animals and fish, gathered natural foods such as roots, grains, herbs and berries that were available to

him and ate them immediately in their raw and unadulterated state, the results were more or less satisfactory and the strong survived. As a result of civilization many changes came, some for better and some for worse, insofar as health and nutrition were concerned. With the development of the machine age, man no longer foraged because he had become a food producer. He has domesticated animals, planted and cultivated the foods he likes best; transports and preserves them so that they are available the year around; cooks and serves his food under a variety of conditions.

Knowledge of food values is a new scientific acquisition. It has been said that the science of nutrition is a necessity which has been called forth because we now eat foods which have been refined and changed until they have lost their native ability to act as a part of this automatic process. For this reason we now need guidance in choosing the amounts and kinds of food to be included in our modern diets. Before gaining our new understanding of the materials and processes of nourishment, civilized man learned to depend too largely upon refined, canned and preserved foods. Instead of the natural, unadulterated, whole-grain cereals with their high nutritive value, he grew to like white bread, white rice, degerminated cornmeal. We have cultivated an appetite for these processed and refined foods and dietary habits have become established which make the return to natural and unrefined foods a real effort.

Abnormal Appetites

If a dietary is adequate in quantity and quality of all nutriments the healthy child will not have an abnormal craving for sweets, especially sugar, a food of high calorie value but low in nutritive value. This fact is substantiated by our observations of the free choice of sugar by healthy children. As diet was carefully adjusted to meet the body requirements of an individual, the child voluntarily reduced his sugar consumption (Figure 4).

When sugar reaches the empty stomach, or a relatively

large amount of sugar is eaten with other food, the body immediately attempts to reduce the sugar concentration of the contents of the stomach. To do this, large amounts of fluid from the body tissues flow rapidly into the stomach and the resulting volume of liquid may stop hunger contractions, with the consequent loss of appetite. A single bottle of "pop" or a few pieces of candy may have a lasting effect because the size of the stomach decreases very slowly as digestion proceeds. This in part explains the satiety and sense of fullness, followed by a cessation of hunger contrac-

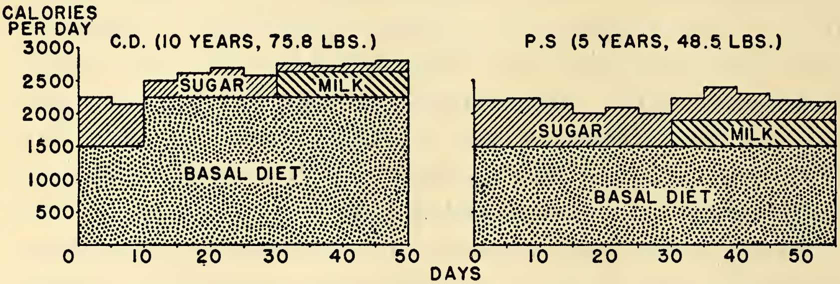


Fig. 4. Voluntary decrease in sugar consumption by two children following increased adequacy of diet.

tions and a submerging of appetite, which follow the consumption of "pop," candy or sweets. The data reproduced (37) in Table 2 were obtained during the course of X-ray studies conducted by the authors and demonstrate the effect

TABLE 2

Average Changes in Size of Children's Stomachs after Ingesting Water and Carbohydrate Test Meals*

Test meal of barium in	Size of stomach after		
	12 minutes	40 minutes	75 minutes
Water (6 oz.)	100 per cent	72 per cent	63 per cent
Sugar solution (6 oz.)	128 per cent	122 per cent	117 per cent

* All of the percentages are based upon 100 per cent as the size of the stomach 12 minutes after ingestion of the water-barium meal.

of ingesting sugar solution on the amount of fluid in the stomach.

Food likes and dislikes enter into the feeding of every family. Appetite is not an infallible guide to good nutrition; it is whimsical, vacillating, subject to prejudice and imitation, and may be altered by conditioning or learning. Appetites vary secondarily with age, customs, temperature and economic status. Each family has food patterns; many of the foods used and the method of preparation are family traditions. Some foods have greater palatability for some people than others. Foods may be valuable in terms of the quantity of nutriments in a given quantity of food, but evaluated on the basis of palatability they may have a low rating among some people. Hence, palatability differences may greatly influence consumption of foods of high nutritive value. Individuals also may acquire dislikes for foods as a result of unpleasant associations with their texture, appearance, consistency, or derivation, for example, organ meats such as kidney, liver, sweetbreads.

Self-selection of Foods

Taste and appetite are not, in general, reliable guides to physiologic needs. There are experimental studies, however, which show that animals, infants and children, if allowed self-selection of a variety of foods, will *tend* to choose those which will promote health; and appetite assures eating the quantity of food needed. Thus, nature has provided mechanisms which would protect animals from the hunger of both underfeeding and misfeeding—if they remained subject to the environment established by nature. Dr. Clara M. Davis (38) has demonstrated that appetite is a basic mechanism, capable of controlling the food intake of infants. Even newly born infants were subjected to the careful test procedures of her research. When they were offered a selection of different milk formulas, they chose the formula which best suited their individual needs, regulated both the frequency and amount of their own feedings with no

difficulty whatever and made excellent gains in size and weight.

Davis (39) has published studies on self-selection feeding of babies who had been exclusively breast-fed. At weaning they were offered a wide variety of natural, unprocessed, unseasoned foods, both cooked and raw. Her menus were composed of 35 foods, including meats, (beef, lamb, chicken, liver, kidney, brain, thymus) sea fish, cereals, (whole wheat, oatmeal, barley, cornmeal, rye) bone marrow, bone jelly, eggs, milk (certified raw milk, certified whole lactic milk) fruits, (apples, oranges, bananas, peaches, pineapple, tomato) vegetables, (lettuce, cabbage, spinach, cauliflower, peas, beets, carrots, turnips, potatoes) and sea salt. A special effort was made to preserve the natural flavor of the foods. The foods were served during each day in four meals. At each meal 12 of these foods were placed before the children on a tray and they were allowed to make their own selection. Each one of their feedings was weighed and the children were observed carefully for several years.

The process of self-selection and self-regulation of the kinds and amounts of the different foods was so successful that the children grew rapidly, had good appetites and were free from digestive disturbances and constipation. Appetite so governed the food intake that the protein consumption level which each baby established was the same percentage as in his first year and was maintained practically constant throughout his early years of childhood. No two children kept exactly the same ratio but each maintained his own individual level. While this study was not designed to prove that appetite is an adequate gauge when children follow the devious pathways of life in the ordinary home and community environments, it does show the selective power of appetite when a wide variety of good, natural, unprocessed and unseasoned foods are provided. No choice was offered between good and bad foods, nor between foods of low and high nutritive value.

In obtaining information upon hunger and appetite, one

may well bear in mind the wisdom expressed by Chittenden (3):

> Knowledge has value in proportion to the benefit it confers, directly or indirectly, on the human race. Every new scientific fact or principle brought to light promises help in the understanding of Nature's laws, and when rightly interpreted and properly applied is sure to aid in the advancement and prosperity of the individual and of the community. Proper methods of living, economical adjustment of the intake to the varying needs of the body, avoidance of excessive waste of foodstuffs and of energy, are all desirable precepts, which rational people presumably are inclined to follow so far as their knowledge and understanding of the subject will permit. Here, as elsewhere, false teaching may be exceedingly mischievous and lead to costly errors; while blind reliance upon customs, instinct, and superstitions is hardly in keeping with twentieth-century progress.

Digestion

When food is taken into the body it is acted upon by the digestive juices as it passes through the alimentary tract and is liquefied and broken down into simple nutriments. The saliva secreted within the mouth, the gastric juice of the stomach, the pancreatic juice, bile and intestinal juices, all carry enzymes which act to transform the foodstuffs into substances which are suitable for use by the body tissues. Enzymes are specific catalytic agents, which in minute quantities act to bring about chemical changes without themselves being used up in the reaction. For example, the salivary secretions carry ptyalin (amylase), an enzyme that converts starch to sugar.

The gastric juice contains protease (protein-splitting pepsin), lipase (fat-splitting) and renin, a specific casein-digesting or milk curdling enzyme (found in largest quantities in infants and other young animals), which act in an acid environment. While the stomach is filled with relative rapidity, the intestine receives the contents of the stomach gradually. As each portion passes from the stomach through the pylorus it becomes subject to the peristalic action of the intestine. The rhythmic contractions of the

circular muscles in the intestinal wall (peristalsis) keep mixing its contents and moving the material onward. Digestion and absorption proceed throughout the length of the small intestine and continue into the large intestine.

Intestinal digestion begins about five or six inches from the pylorus, the opening from the stomach. In this region the secretions from the liver and pancreas empty into the intestine and combine their action with that of the intestinal secretions to induce rapid and powerful enzyme action. The secretions of the small intestine, pancreas and gall-bladder act in an alkaline medium to break down the remaining proteins, fats and carbohydrates into their digestion products, preparing them for absorption from the intestinal tract. Carbohydrates are split into sugars, fats into fatty acids and glycerol, and proteins into amino acids.

The digestion products are absorbed from the intestinal tract into the blood stream and so made available to every part of the body. From the nutriments brought by the blood, each tissue selects those it needs to carry on its vital functions. In the large intestine, material excreted from the body may be added to the residues from digestion. In infants the length of the small intestine is approximately eleven feet and of the large intestine over two feet. In the adult, the lengths are thirty feet and five feet.

Constipation

Constipation may result from improper diet, irregular habits or psychological inhibition as well as from disturbances caused by disease. An adequate diet furnishes a proper amount of bulk, along with the essential nutriments, which aids in maintaining proper intestinal activity and elimination of waste products. The intestinal tract supports various types of bacteria which carry on extensive activities, some of which may be beneficial and others detrimental. Beneficial bacteria act upon and to some extent break down the complex carbohydrates of young, tender, vegetable fiber (hemicellulose, cellulose, lignin) so that the body can absorb and

utilize materials that otherwise would be unavailable. They may also contribute essential nutriments through their processes of synthesis. While some bacteria cause putrefaction and the formation of undesirable substances, the presence of other bacteria is essential for health and there is no need for concern over intestinal intoxication and constipation in a healthy individual who eats a properly balanced diet, follows the rules of hygiene, and lives according to a well-organized regimen which includes plenty of rest and exercise.

Metabolism

The term metabolism is used to designate the processes by which the digestion products, after they are absorbed from the intestine, are used by the body. These products provide the energy for all the work performed by the body and the materials for the construction of body tissue in response to the demands for growth, maintenance or repair. The tissue constructed as "growth" contributes to the increase in size with which the term is generally associated, but throughout life cells of the various parts of the body are being destroyed and replaced by new ones—the process of maintenance. In addition, new tissue must be formed to "repair" the ravages of disease and destruction resulting from accidents.

Chapter Four

POOR NUTRITION—POOR HEALTH

Nutritional Status

Only a few years ago weight and height were thought to be good indices of nutritional status, but nutrition research has demonstrated that these mean little. The chemical composition of a pound of weight gained or lost is extremely variable, for example, a child may remain at the same weight for three or four months, or may actually lose weight, but by chemical analyses of the food eaten, and the urine and feces excreted, the child may be shown to be building both bony and muscle tissue. Thus, change in weight may represent only a gain or loss of water and perhaps fat, and give no indication of nutritional status.

At the Round Table on Nutrition, Twentieth Annual Conference of the Milbank Memorial Fund, Dr. H. D. Kruse (40) presented A Concept of the Deficiency States embodying the most recent knowledge of nutrition sciences.

> Study of the pathogenesis of deficiency diseases makes the existence of an early or mild state thoroughly understandable. A deficiency disease on a dietary basis develops in the following sequence: lowered concentration of the essential factor in the blood; depleted storage in the body's reservoirs; diminished excretion in the urine; microscopic change in tissue; gross morphological and functional change. It is not to be inferred, however, that each step is completed before the next begins. The alteration in transport and storage and the microscopic change in tissue show that the disease does exist in a state which is undetectable by ordinary clinical methods. For most deficiency diseases these changes have been demonstrated by appropriate sensitive methods.

Methods have been developed for determining many of these changes and are now being used widely. While many tests are still in the experimental stage and there may be some variation in the interpretation of the results, a real step

forward has been made in a better understanding of nutritional status. Certainly they are far better than the measurement of heights and weights alone.

Although it has been human perseverance and ingenuity that have brought conquest of dread beriberi, of the curse of scurvy and the misery of rickets and pellagra, the exploration and conquest of the great borderline of sub-clinical malnutrition is just in its initial stage of development. Here in the United States, fullblown cases of scurvy, beriberi, pellagra and rickets do occur, though the numbers are not large. Colonel Leonard G. Rowntree, Chief, Medical Division, Bureau of Selective Service of the War Manpower Commission, in November, 1943, at the Postgraduate Assembly on Nutrition in Wartime, Institute of Medicine of Chicago, stated that the results of an analysis of a sample of reports on physical examinations of registrants showed that 3.2 per cent of the men had defects specifically and almost solely due to nutritional deficiency. These defects included beriberi, scurvy, pellagra, malnutrition, rickets, nightblindness and underweight. He emphasized that the prevalance rate of 3.2 per cent was an understatement because it concerned only primary nutritional deficiencies and would be raised to 43 per cent when secondary nutritional diseases are included.

New methods of diagnosis for subclinical malnutrition are being developed through the combined efforts of biochemists, physiologists and physicians. By whatever tests used, the amount of undernutrition and malnutrition in the United States appears to be large. Subclinical malnutrition persists in our population because its expression is below that level which demands the immediate attention of a physician. The individual is usually in "poor health" though he is most often unconscious of any specific damage. Graubard (27) states that the individual experiencing subclinical deficiency

> . . . is in the position of someone born without a sense of pain. . . . It (pain) serves to notify the individual that something is amiss which requires immediate attention. In the absence of a sense of pain, the cause

of the disturbance is allowed to persist and expand. Subclinical effects of malnutrition do not bring pressure upon the individual. Their detection is not always easy though their consequences may become apparent when it is too late.

We are aware that pellagra is common in the South and that cases of scurvy and rickets appear occasionally in the North. Nutrition surveys show that large numbers of our population suffer from one or another deficiency, but there are those who blind themselves to their existence. One official of the United States Public Health Service, during the course of a field trip, was met by a local health officer who told him that he would find no deficiency diseases in that section. The Public Health representative just looked at the health officer and said, "But what is the matter with the corners of your mouth"? The health officer gave some excuse but went on to enumerate other symptoms which were typical of ariboflavinosis. His symptoms were cleared by treatment and since that time he has found many other cases like his own. So that health officer is now a believer in the newer knowledge of nutrition and is influencing many others in his locality.

Problems of nutrition are problems of health. Without retreating from the battle for recognition of the immense possibilities of nutritional science in treating disease and dysfunction *after* they have occurred, the gigantic opportunity for nutrition is in their *prevention*—the promotion of health. As Dr. John A. Ryle (41) has put it:

So confused has been our thinking about health that when at length we begin to consider it as a proper professional concern we allow a curious term like "positive health" to creep into our terminology—as though there were some other sort of health that was "negative." The old English word "hale," which means healthy, is etymologically the same as "whole." The healthy man is the "whole man," whole in a functional regard, in the enjoyment of his faculties and well adapted to his environment. Health, like disease, and similarly in its time-behaviour, is a continuing and fluctuant rather than a static process; its features vary with age, sex and other circumstance. Between health and disease, be

it admitted, there is no sharp and clear-cut boundary. Nevertheless it is important to accept that health is something different from the state of "no demonstratable disease" with which it has been too readily confused. Young army recruits are enrolled in their thousands under category A1, but their rapid gain in weight and improvements in respect of appetite, bearing and efficiency under the influence of good food, fresh air and physical training suggest that, although "no disease" was found at the medical boards, "A1" and "healthy" are not identical, and that the conditions requisite for health could not have obtained in the previous civilian life and work of a large proportion of Service men and women.

* * *

It is clear that health is something worthy of study for its own sake and for the better applications of knowledge to its promotion and maintenance. It has, like disease, its causes, its manifestations and its consequences, about which a great deal remains to be discovered and towards the better understanding of which methods of observation and experiment already employed in the clinic could be readily adapted. Too many of our "normal" standards employed in the ward and the laboratory have been based upon the examination of patients. In consequence we have seen a world-wide acceptance of uncontrolled tests or methods and the creation of countless invalids through the findings of the stethoscope, of radiography and of each new endoscope, findings which often represented no more than the range of "normal" variability.

Under the conditions of ordinary times United States wage earners are absent from their work on account of illness at least one-quarter million working days per year (42). This is a constant annoyance and an economic waste to both employer and employee. Studies by sick benefit associations show that almost one-half of the time lost by wage earners is caused by colds. The medical department of the Eastman Kodak Company, under the direction of Dr. Wm. A. Sawyer (42), more than a decade ago pioneered in applied nutrition as an aid to reducing absenteeism. He demonstrated that if the home diets were supplemented by milk and other protective foods at the factory, the well being and efficiency of the industrial workers were materially improved. Furthermore, absenteeism due to colds and respiratory diseases was only 1.1 per cent of the total possible working hours among the workers receiving the food supplements in con-

trast to 3.1 per cent among those not receiving the special supplements. Many studies inaugurated during the war emergency verified and extended the findings of improving health and efficiency through applied nutrition. The wisdom of the slogan "better foods for better health" if properly applied can contribute to health, happiness and the betterment of the human race.

In a survey of American diets made by Dr. R. R. Williams (43) the total quantities of the following nutriments in a hypothetical, 2,500 calorie diet for the average man in sedentary activity were: 0.8 mg. thiamin; 1.4 mg. riboflavin; 11 mg. niacin, as compared with the National Research Council recommended allowances of 1.5 mg., 2.2 mg. and 15 mg. respectively.

Corry Mann demonstrated that nutritional improvement is accomplished by feeding milk with the lunches of school children (44). The Department of Health for Scotland studied 12,000 children during a three-year period in which they were given a milk supplement daily, at school. The results of these large-scale studies substantiated Mann's findings (45). Even in a dietary deemed adequate according to current standards, milk can enhance mental and physical development. Wiser feeding is one of the major factors in the finding that girls and boys now enter college, on the average, younger and taller than formerly.

If one-half to two-thirds of the population of the United States is underfed or poorly fed, is it not fair to assume that a similar proportion of the future mothers are improperly fed? There is every reason to believe that a large portion of these mothers of tomorrow are both underfed and malnourished. They possess little bodily reserve and "hidden hunger," no doubt, prevails in their bodies to the extent of malnutrition caused by the failure to consume adequate diets, by conditioning factors that interfere with the ingestion, absorption or utilization of essential nutriments, or by factors that increase their requirement, destruction or excretion. If the mother at the time of conception is malnourished, this

is the first in what may prove to be a series of unfavorable incidents in the life of her offspring.

It is well known that pregnancy may interfere with the ingestion of adequate amounts of food; it may interfere with the digestion of food, and it does increase the nutritive requirement. Lactation, also, increases nutritive requirements and increases the excretion of substances from the body, especially through the milk. These conditioning factors must be taken into consideration when planning the

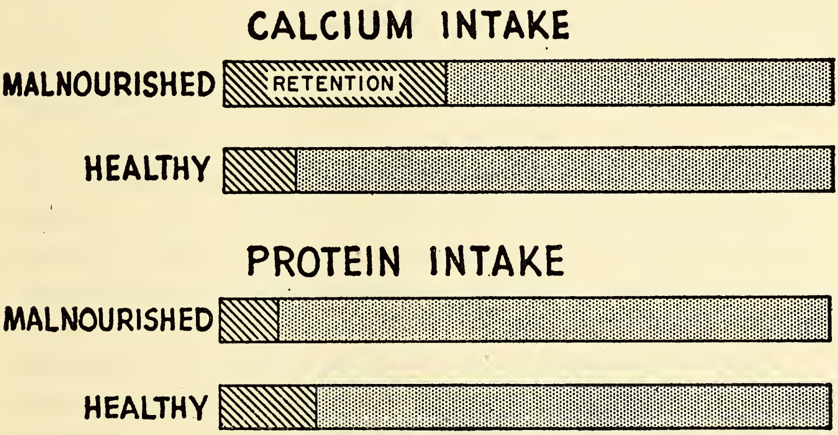


Fig. 5. Percentages of intakes of calcium and protein per kilogram of body weight retained by two pregnant women while they were receiving diets which provided, daily, a total of 36 to 41 mg. of calcium and 1.5 to 1.6 gm. of protein per kilogram of body weight.

dietary allowance for an individual during pregnancy and lactation. Figure 5 demonstrates the differences in protein and calcium utilization from adequate diets by two pregnant women, one of whom had been malnourished from childhood. Nutritional reconditioning is a lengthy process. If started early in and continued throughout pregnancy, it would be a great boon to both mother and child.

Malnutrition

Too long has the term *malnutrition* been used loosely—frequently to cloak a heap of ignorance. Malnutrition (bad nutrition) is a general term which indicates nutritional

failure varying in severity over a wide range. It may indicate only slightly inferior nutritional status produced by failure to provide *all* of the requirements of good nutrition: the right foods and ample amounts at the proper time, adequate amounts of rest and exercise, and favorable environment. Malnutrition may occur also in the presence of dietary adequacy. Kruse (40) points out that failure should denote a deficiency in the body tissues rather than in the diet. If a nutritional deficiency arises from an inadequate diet it should be considered a *primary* deficiency. If it is caused by factors other than an inadequate diet, it should be considered as a conditioned or *secondary* deficiency. Conditioned deficiencies are caused by factors that interfere with the ingestion, absorption or utilization of essential nutriments or by factors that increase the requirement for them, destroy them in the body, or cause them to be excreted. For example, pregnancy may be a conditioning factor and cause malnutrition by interfering with the ingestion of food, or by increasing nutritive requirements.

In general, malnutrition involving conditioned, or secondary, deficiencies as the result of disturbances of body function and as the sequelae of disease, together with the gross manifestations of malnutrition recognized as deficiency diseases, are acute medical problems which call for therapy based on individual diagnosis. In such cases the physician must evaluate the role of the nutritional and the other factors involved, determine whether the deficiency is "cause" or "symptom" and prescribe the treatment indicated. With some cases secondary deficiencies can be treated simultaneously with primary therapy; in other cases application of results of nutrition research must await control of disease or dysfunction; and in still other cases the therapy necessary to bring an illness under control may cause, or aggravate, a nutritional disturbance. The public health aspect of nutrition, insofar as it involves "prevention," is concerned with averting nutritional failures, thus eliminating the cause of primary deficiencies and reducing the number of causes of

conditioned, or secondary deficiencies. In this objective the approach is to malnutrition as the result of underfeeding or misfeeding, or both.

*Under*feeding consists of eating inadequate amounts of food. Poverty is the greatest contributor to underfeeding, commonly designated as "hunger" ("hollow hunger" by some). Without the money to purchase *enough* food, little can be accomplished by recommending better, but more expensive, foods. War, famine and pestilence may cause hunger by reducing food supplies and economic forces may act to prevent people of some areas from obtaining enough food to satisfy their hunger. It is obvious that underfeeding is necessarily misfeeding.

*Mis*feeding is a much larger problem than underfeeding. With sufficient food to allay hunger the diet still may not be adequate in meeting the chemical needs of the body. Further, even with a diet adequate in all respects, physiologic factors may prevent proper use of the food materials by the body. The consequences of misfeeding are frequently designated as "hidden hunger." Lack of education and indifference are major factors in misfeeding. Misfeeding also results from failure to make special provision for increased needs for certain nutriments during periods of stress in the life cycle or under conditions which make more stringent demands upon the food eaten. Misfeeding may continue for months, or even years, without producing deficiency disease or any specific symptom of dietary failure. The clinical evidence of nutritional failure may consist only of deterioration of the teeth, headaches, mild gastrointestinal upsets or other such vague complaints. The physicians and dentists must be alert and well-informed on matters of nutrition to differentiate such patients from actual neurotics. In other instances misfeeding may occur over short or long intervals without causing complaint by the individual. With children, especially, chronic misfeeding which may date from birth frequently results in the body becoming "conditioned" to a poor diet. While such bodies do not make a physiologic

protest against the lack of proper nourishment, the results are demonstrated by poor nutritional status. There is no doubt that poor nutrition over extended periods in childhood produces an adult of inferior physique, less stamina and resistance to disease and with the prospect of a shortened life.

Subclinical Malnutrition

Many different substances must be furnished in the daily diet if a strong body is to be built and maintained; health cannot be maintained without the necessary amounts of body fuel, minerals, vitamins, amino acids, fiber, and liquid —all of which must be provided by foods. Indeed, nutrition research has demonstrated that there are approximately 40 substances which are necessary components of the diet. In *Good Nutrition for Everybody* (46) Dr. L. Jean Bogert points out: "Following the best kind of diet cannot absolutely guarantee health, for many are born with physical handicaps, accidents happen, and germs lurk about; but a lifetime habit of taking a poor diet is sure to result in ill-health."

People who through ignorance are unaware of the importance of food, those who follow the latest food fads and fancies and those who are lazy make up the majority of the misfed group. A diet consisting of meat, potatoes, white bread, pie and coffee is unbalanced because it does not supply the essential needs of the body, although it may satisfy the appetite and allay hunger. The cells of a body subjected to this diet day after day may be starving for some nutriments that are required in only small amounts. Consumption of an inadequate diet over a prolonged period of time will lead to disease and physical degeneration. This condition has been called "hidden hunger." To make sure of getting a "balanced" diet that will satisfy all the requirements of the body, some interest in, and awareness of how to choose foods wisely is a necessity. Groups with low incomes especially need instruction in how to secure the best food value for their money if they are to eat food which will meet all the body needs at low cost (Figure 6.).

Approximately four decades ago Chittenden concluded his classic book, *The Nutrition of Man* (3) with:

. . . the nutrition of man, if it is to be carried out by the individual in a manner adapted to obtaining the best results, involves an intelligent appreciation of the needs of the body under different conditions of life, and a willingness to accept and put in practice the principles that scientific research has brought to light, even though such principles stand opposed to old-time traditions and customs. The master words which promise help in the carrying out of an intelligent plan of living are moderation and

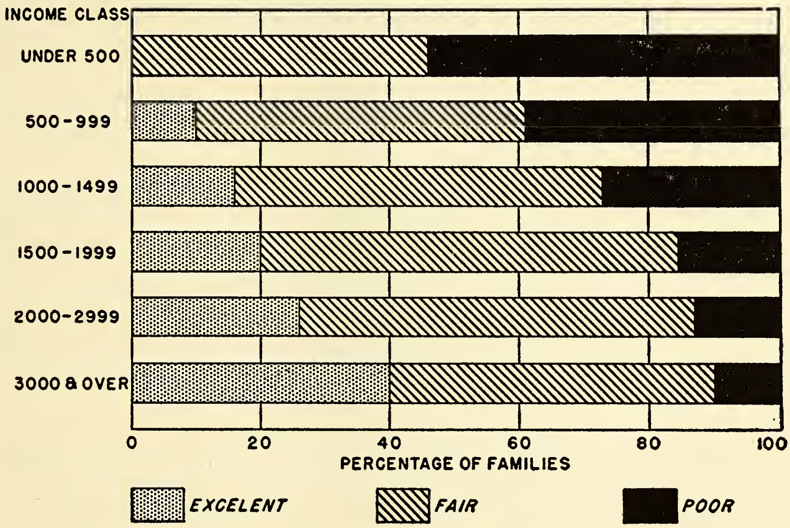


Fig. 6. Percentage of families in various income classes having diets of specified nutritive value (75).

simplicity; moderation in the amount of food consumed daily, simplicity in the character of the dietary, in harmony with the old saying that man *eats to live* and not lives to eat. In so doing there is promise of health, strength, and longevity, with increased efficiency, as the reward of obedience to Nature's laws.

In May, 1941, reports at the National Nutrition Conference for Defense (17) showed that 45 million persons in this country consumed diets that were inadequate, even by the most conservative standards. A very large proportion of the population was handicapped because of poor nutrition. Over 40 per cent of the young men of draft age were not physically fit. Many of them showed defects that could

have been prevented by proper nutrition, according to Dr. Thomas Parran, Surgeon General of the United States Public Health Service. Dr. Parran believes that the prevention of and proper treatment of diseases in which nutrition is the causal or a contributing factor constitute one of the greatest medical problems in this country.

One of the most important effects of World War II upon the development and application of the science of nutrition has been the recognition of subclinical or incipient deficiency states. The results of surveys, experimental research and selective service examinations have provided new knowledge which clarifies the nutrition problems of the nation and indicates approaches which will reap the maximum in benefits to public health.

A report of the Committee on Diagnosis and Pathology of Nutritional Deficiencies, of The National Research Council (47) gives the results of a very intensive and critical analysis of the literature on the prevalence and significance of Inadequate Diets and Nutritional Deficiencies in the United States. In summarizing, the report states that:

> All these surveys, without exception, revealed similar results: marked prevalence of dietary inadequacies as judged by recommended standards. The evidence is consistent. From all the reports it is evident that very many persons are not receiving the recommended amounts of dietary essentials. Accordingly, the evidence that such a large proportion of the population is eating unsatisfactory diets points to possible widespread prevalence of deficiency states. Indeed, inasmuch as diet surveys have limitations and other factors besides diet enter into the production of deficiency diseases, it is possible, if not probable, that deficiency states are more prevalent than indicated by results of dietary surveys.
>
> Even when the diet seems to contain sufficient amounts of essentials, its adequacy is often apparent rather than real. Its adequacy is usually estimated from calculated values. It is well known that heat markedly destroys vitamin C, and it has recently been demonstrated that light causes destruction of riboflavin in food. Accordingly, analysis of prepared food shows much less than the estimated amounts of these essentials. Usually in estimates of diets allowance is made for loss of vitamin C by heat, but the deduction is often too small. No allowance is made for the destruc-

tion of riboflavin by light. Hence, diets adequate by calculation may really be deficient.

. . . Few persons have had a good diet throughout life. Unless a perfect diet has been eaten regularly, deficiency states will not have been prevented and nutrition will not be perfect. Slight deficiencies are apt to be ignored as if they were without effect. Nor must the diet have been unsatisfactory over the entire past to lead to this undesirable state; it may have been poor for a short time or at intermittent periods. Persons who proudly assert that their diet *is* exemplary seem to overlook their past record until prompting reminds them that their diet has been satisfactory only for the last few years, that it was unsatisfactory for a longer or shorter period in the past. They are apt to live in a false sense of security in the belief that the change to a satisfactory diet immediately and automatically expunged the consequences of their past unfavorable record. Kruse has pointed out that time and degree of deficiency are important in the evolution of deficiency states. Deficiencies occurring periodically or persisting over years produce cumulative effects. Slight deficiencies lead to cumulative effects just as truly as marked deficiencies. Partially, indeed slightly, deficient diets eaten regularly and periodically over many years have their consequences. Such conditions are very common. For these reasons, deficiency states are more prevalent and severe than indicated by dietary survey.

Even when diet actually contains the recommended amounts of essentials for basal needs and the body is functionally sound, deficiency states may still occur. The standards of dietary essentials are average and make no allowance for individual differences and all increased needs. In a review of this topic Jolliffe has pointed out that certain conditions known as conditioning factors raise the requirements for essentials above the basal level. First, sex and age are indices of increased need: the former because of pregnancy and lactation; the latter because of growth. Secondly, physical exertion raises requirements for essentials. When persons with acute pellagra are kept in bed, even though they be given a pellagra-producing diet, their pellagra temporarily disappears. Thirdly, exposure to light has been reported as increasing the need for certain essentials, particularly riboflavin, nicotinic acid, and vitamin A. Fourthly, exposure to toxic substances increases bodily needs for essentials. Alone, any one or all of these several factors do not produce deficiency states but they may exert a determining or occasioning influence.

Kruse (40) classified deficiency states with proper recognition of the factor of "time" interval, which may be long or short in the development of the deficiency and is paral-

leled by a corresponding rapidity of recovery after the casual factor is eliminated. As he states:

In the past the mild and chronic states have received only sporadic and scant notice. By nature they have not been likely to attract attention. The mild are not conspicuous; indeed, they are below the level of unaided perception. Their associated symptoms, though often troublesome, are not so intense as to be unbearable or to necessitate medical consultation. Often the patient is unaware of symptoms until therapy has brought relief. The grossly perceptible chronic process comes on so gradually and insidiously as not for a long time to be obtrusive. Only in the advanced stages is it likely to draw complaint. Though noted often, little significance has been attached to it. Its relation to nutrition has been unrecognized.

Since the chronic state of deficiency diseases has not been commonly recognized, it is worth while to mention some of its characteristics. Its essence is time. For persons this is age. The longer persons live, the more chance they have to incur changes and to have them develop to an advanced state. Consequently, chronic changes are seen with greater frequency and in the latest stages with increasing age.

. . . In the past these chronic alterations have been called senile changes with the implication that senility causes them. But senility *per se* is not responsible for them. That has never been a satisfactory explanation. Not all elderly persons show the changes. On the other hand, they occur in children. Time, not senility, is the essential point. And time does not start the changes, it simply is a dimension over which they progress. They are specific avitaminoses in a state of chronicity, due usually to respective dietary deficiencies running over a period of years. Their prevalence and severity vary with the number and degree of deficient diets and therefore with economic level. Most important of all, they are reversible, yielding slowly but completely to appropriate therapy.

Late in 1941, at a conference (48) stimulated by the Rockefeller Foundation, a group of authorities with special training and wide experience in nutrition and public health agreed upon a tentative list of procedures and tests which would be acceptable for use in mass surveys of population groups. The Conference recommended that the Nutrition Division of Defense, Health, Welfare and Related Services be asked to prepare working tables of food composition which could be used generally. The group endorsed the Recommended Dietary Allowances of the Food and Nutrition Board of the National Research Council as the standard reference for

nutritive requirements and affirmed the criteria recommended by that Board for recognition of early nutritional failure from physical examinations. The symptoms *suggestive* of early deficiency states in infants and children and in adolescents and adults are given in Table 3.

TABLE 3

SYMPTOMS SUGGESTIVE OF EARLY DEFICIENCY STATES

In Infants and Children	*In Adolescents and Adults**
1. Lack of appetite	1. Lack of appetite
2. Failure to eat adequate breakfast	2. Lassitude and chronic fatigue
3. Failure to gain steadily in weight	3. Loss of weight
4. Late period of sitting, standing, walking	4. Lack of mental application
5. Aversion to normal play	5. Loss of strength
6. Chronic diarrhea	6. History of sore mouth or tongue
7. Inability to sit	7. Chronic diarrhea
8. Pain on sitting and standing	8. Nervousness and irritability
9. Poor sleeping habits	9. Paresthesias [Morbid sensation]
10. Backwardness in school	10. Night blindness
11. Repeated respiratory infections	11. Photophobia [Light intolerance]
12. Photophobia	12. Burning or itching of eyes
	13. Lacrimation
	14. Muscle and joint pains, cramps
	15. Sore bleeding gums

* May exist in absence of underweight or other evidence of undernourishment.

Dr. Norman Jolliffe (49) has emphasized the role of conditioning factors in the occurrence of nutritional inadequacy and the developmental stages of its resultant, malnutrition. Their relationship is shown in Figure 7.

Nutritional inadequacy ⟶	Malnutrition
May be caused by:	The successive stages of which are:
1. Dietary inadequacy	1. Tissue depletion
2. Failure to absorb	2. Biochemical "lesions"
3. Failure to utilize	3. Functional changes
4. Hastened excretion	4. Anatomic lesions

FIG. 7. Nutritional failure.

In summarizing the problem of deficiency states in medical practice Jolliffe (50) comments:

> The term malnutrition signifies not a dietary inadequacy but a tissue deficiency of an essential nutrient. This tissue deficiency may be caused by the failure to ingest an adequate diet. This tissue deficiency may also be caused by factors which interfere with the ingestion, absorption or utilization of essential nutrients or by factors that increase the requirement for vitamins, their destruction or excretion. These are known as conditioning factors and when a deficiency disease is produced through their mediation it is known as a conditioned deficiency disease, or conditioned malnutrition. . . . many diseases and some of the therapeutic measures used to combat them interfere with nutrition and are potent factors in the production of deficiency diseases. It is also an inescapable conclusion that the treatment of malnutrition is in each person an individual medical problem requiring exact diagnosis and therapeutic measures which cannot with safety be left in the hands of non-medical persons. The physician who does so is derelict in his duty to his patient.

Effects of Underfeeding and Misfeeding

The consequences of too little food are in direct proportion to the degree of inadequacy of the intake and its duration. It is probable that slightly low food intakes which are fairly adequate in their distribution of nutriments may leave no permanent nutritional effect after the diet is improved or the rate of growth slows. Severe shortages in the food supplied to the body may retard growth and cause deficiency diseases, leaving as residual effects permanent limitation of growth and organic defects and weaknesses. Deficiencies of a single nutriment seldom occur as the result of underfeeding, for diets which are inadequate in quantity are usually inadequate in several essential food constituents.

Misfeeding may provide an intake of insufficient amounts of only one or of several nutriments which are essential for health and may be the direct result of eating too large amounts of one type of food or too small amounts of food containing certain substances. In the first category falls the well-known malnutrition resulting from too large con-

sumption of candy, soft drinks and other sweets, with consequent loss of appetite and failure to eat ample amounts of foods which contain protein, fat and protective factors. Eating too small amounts of foods containing specific essentials is frequently dictated by poor food habits, superstition, profit motives, or geographic locations where those foods are expensive and not readily available. Dietary calcium deficiency is common, even among rural populations. Without milk and cheese in the diet it is almost impossible to supply the growing body with ample amounts of calcium from foods. Even in milk-producing areas, failure to include sufficient amounts of dairy products in the diet has resulted from the desire for cash return from the milk.

The phenomenal development of the science of nutrition during the present century has been paralleled by advances in all phases of the medical sciences. Methods of differential diagnosis have been greatly refined, permitting quicker, more accurate evaluation of illnesses and providing morbidity and mortality data of much greater reliability. The value of these new developments has been demonstrated by the selective service examinations of World War II. More refined examination procedures have not only given us valuable information upon the incidence of respiratory and other disturbances but also have uncovered many unrecognized conditions requiring medical treatment, such as incipient tuberculosis and heart disease. Discovery of these cases in their "early" stages has made it possible to inaugurate treatment and obtain better and quicker results, thus contributing to improving the health of the population. Clinical medicine has made equally great strides in applying the new knowledge of pharmacology, physiology and nutrition to the treatment of communicable and deficiency diseases and to their prevention. As the mounting evidence of experimental investigations continues to emphasize the serious consequences of malnutrition, efforts to prevent its occurrence have been given a more prominent position in the practice of medicine, in the activities of public health

and social service agencies, in the management of industry, and in the objectives of government.

Weight

Overweight is the accumulation of *excessive* amounts of fat in the body. The most common causes are over-eating and lack of sufficient exercise. People who are not active yet eat heartily become overly fat because they take in more energy-bearing food than their bodies need. The tendency to consume more food than they need and exercise less is common among people past middle-life. Also, overweight may be caused by failure of the glands of internal secretion to function properly, particularly the thyroid, the pituitary and the sex glands. Overweight in some individuals is accompanied by a predisposition to diabetes in later life. Diabetes with this casual factor can usually be controlled by reducing the body weight to normal and thereafter taking a well-balanced diet containing only enough calories to meet the body requirement.

Excess weight overtaxes the heart, contributes to fatigue, impairs vitality and reduces normal life expectancy. The conquest of obesity from over-eating can be attained by eating only the food required, and indulging in healthful exercise. It is a simple matter to remove five or ten pounds from an overweight body merely by reducing the total calorie consumption and increasing exercise. If it is necessary to remove large accumulations of excess fat to attain normal weight and increase life expectancy, the process should be accomplished slowly under the guidance of a competent physician.

True "underweight" is not determined necessarily by nonconformance with tables showing average weights for sex and height, but is a result of malnourishment. Underweight may be caused by inadequate food consumption, poor dietary habits, indigestion, fatigue, disease, physiologic abnormality, anxiety, and hypersensitivity. The undernourished individual is a good prospect for tuberculosis,

infections of other types and deficiency diseases. McCollum and Simmonds (51) have stated that "It is not sufficient for the purpose of putting on flesh to overload the body with as much fat-forming food as possible. It is a matter of first importance that *the basis of the diet be a supply of such foods as will adequately provide for the maintenance and replacement of the daily wear of the tissues, and for the support of normal functioning of the organs of the body.*"

If underweight is the result of infection, medical aid should be sought to eliminate the source of infection. Malnourished people frequently eat insufficient food because of faulty habits of living. They may eat between meals and spoil their appetites for regular, well-balanced meals; they may have misconceptions of what foods are best for them and eat according to their personal dictates; they may be emotionally high-strung and get insufficient rest. Physical exhaustion not only demands extra rest but a diet composed of generous amounts of fruit, vegetables, milk, eggs and animal proteins. Besides eating liberal servings at the regular mealtime, it may be necessary to add extra nourishment before retiring.

Improper dieting to attain a sylph-like form, such as going without breakfast and eating limited and unbalanced lunches, is one of the major contributing factors in the increase of tuberculosis among high school girls and the inability of young mothers to bear and rear healthier babies and at the same time maintain their own health. Intensive educational campaigns are needed to teach preadolescent and adolescent boys and girls that "it is smart to be healthy."

Oral Conditions

One of the most difficult problems in public health is the high incidence of dental caries (decay). Of the first 900,000 rejections by selective service in World War II, twenty per cent were attributable to dental defects (52). There is confusion concerning the etiology of dental caries. There are geographic locations where the incidence of dental

caries may run as high as 80 to 95 per cent of the population and others where it is conspicuously low. Too many sweets in the diet may, either directly or indirectly, increase dental caries, as has been shown by Dr. Russell Bunting, (53) Director of the School of Dentistry, University of Michigan. Dr. Percy R. Howe (54) and colleagues of Forsyth Dental Infirmary for Children, Harvard Medical School, years ago showed experimentally that a poor diet, low in vitamins C and A, and calcium, predisposed to poor dental conditions. He also demonstrated, and it has been confirmed by Drain and Boyd (55) of the University of Iowa Medical School, that an improved diet including the use of meat, milk, fruit and vegetables is followed by a reduction in the occurrence and severity of caries. Lady May Mellanby (56), who, in England, was the first to develop dental caries experimentally in dogs on diets deficient in calcium and phosphorus, as well as vitamin A or vitamin D, has clearly shown that supplements of these nutriments to the usual diet improved the dental conditions of children. Better nutrition contributes to dental health, as it does to general body health. Although controversy exists on the cause of dental caries, there is increasing evidence to prove that an ample well balanced diet is essential for oral health and sound tooth structure.

Protein Deficiency

If the diet of a normal *adult* person contains adequate amounts of protein, the amounts of nitrogen excreted (chiefly as urinary nitrogen) equals the nitrogen content of the food (largely protein nitrogen). This situation is termed nitrogen balance or equilibrium. When protein is being synthesized in the body in response to the demands of growth, pregnancy and lactation, the nitrogen excreted is less than the nitrogen intake. In such cases the individual is retaining or storing nitrogen (protein) and is said to be in positive nitrogen balance. Nitrogen may also be retained for use in replacing "worn out" tissue or repairing injury

from accident or disease. When nitrogen is excreted in excess of the amount in the food, the condition is known as negative nitrogen balance and is the result of either an inadequate intake of protein or the excessive breakdown or wastage of body protein associated with disease. A possible exception is an inadequacy of dietary protein or a certain essential amino acid for a short time only.

Handler and Featherston (57) in studies of anemia consequent to niacin deficiency, in dogs, stated that

> during the period in which the anemia developed, dogs frequently lost as much as 60 per cent of their original body weights. Further, while the hematocrit (percentage volume of red blood cells in the blood) dropped from 50 to 25 per cent, there was also a marked decrease in the plasma volume. Consequently, while the hemoglobin concentration, in gm. per 100 cc., was reduced to perhaps 30 per cent of its original level, the total circulating hemoglobin decreased, in most instances, to but 15 per cent of its initial value. . . . From these data it appears that when the cause of a metabolic disturbance which has produced a loss of body weight, plasma proteins, and hemoglobin is removed, dietary protein is utilized first to restore the normal hemoglobin concentration, then plasma protein concentration, and finally to synthesize tissue proteins and restore body weight.

Recent studies with human beings, though relatively short, have indicated that certain specific lesions may result from an inadequate intake of an essential amino acid yet the nitrogen balance remains positive. Some tissues are more labile than others, or, more specifically, certain tissues may have priority over others in acquiring the essential amino acids. In this respect, lymphoid and certain glandular tissues may give up part of their protein or amino acids to nervous, circulatory or muscle tissues where the need may be greater when dietary intake is inadequate. However, this condition can only be temporary for with prolonged ingestion of a diet inadequate in protein a deficiency results.

Nutritional edema is the name given to the pathological state arising from a deficiency of protein in the diet. It is known also as *prison dropsy*, hunger swelling, famine, starvation or war edema. Attention was focused on this disease

during the latter part of World War I when a large number of cases appeared in Germany among the civilian population and prison camps. Continuous ingestion of a diet low or inadequate in protein results in decreased blood plasma protein, particularly the albumin fraction. When the plasma level falls, water from the blood is lost to the tissues, which swell and become edematous. This condition usually appears first in the lower extremities, but may extend to all parts of the body. Gastrointestinal disturbances, muscular weakness, anemia and emaciation may be associated with the edema.

War and the resultant famine produce epidemics of nutritional edema, particularly among the poorer classes of the population and it is not uncommon in normal times to find large numbers who consume inadequate amounts of protein. Dr. John B. Youmans (58) found many diets in Tennessee below the recommended allowances of the Food and Nutrition Board, with many below even the generally accepted minimum for satisfactory protein nutrition. The adequacy of the protein intake depends to a large extent on total calories. If the calorie intake from fat and carbohydrate supplies the energy need, protein need not be burned as fuel. Deficiencies are found in the intake of calories, in the absolute sense as well as relative to the protein intake, and the intake of animal protein is often low. Protein adequacy depends not only upon the quantity but also upon the quality (biological value) of the protein eaten, therefore it is important in the aleviation as well as in the prevention of protein deficiency that proteins of the best quality are included in the diet. Such proteins as those of milk, meat, egg and soybean are highest in biological values and have top ranking in their ability to promote regeneration of plasma protein.

Vitamin A Deficiency (Xeropthalmia)

A deficiency of vitamin A produces lesions in the epithelial tissues (skin and mucous membrane) of the body, particularly in the eyes and skin. Lack of sufficient vitamin

A hinders or prevents the regeneration of the visual purple in the retina and the resulting night-blindness may manifest itself as difficulty in seeing or reading in dim light, in finding a seat in the theater, stumbling in the dark or in driving a car at night, particularly against bright headlights. Reduced speed of adaptation to decreases in light, early night-blindness, appears to be among the first signs of vitamin A deficiency. Manifestation of more severe deficiency or of longer existence is inflammation of the conjunctiva (mucous membranes of the eye). With xerophthalmia these membranes become dry, tears cease to flow and infection may occur. If not corrected, ulceration with complete loss of sight usually follows. Congenital blindness (at birth) resulting from vitamin A deficiency during pregnancy has been demonstrated, with pigs, by Hale (59).

The skin lesions, first described in Chinese soldiers, usually consist of small papular (pimple) eruptions of the skin, particularly on the arms, legs and body trunk. The skin is dry and rough and may have a "gooseflesh" appearance. Lack of vitamin A may affect other organs and tissues of the body such as the urinary tract, the kidneys, the respiratory tract, the teeth and the thyroid gland.

Thiamin (*B_1*) *Deficiency* (Beriberi)

The characteristic symptoms of thiamin deficiency (beriberi) are the result of damage to the nervous and cardiovascular systems. The end result is paralysis and heart failure. In the so-called "dry" type of this disease the neuritis or nervous disorder predominates and in the "wet" type the edema resulting from heart disease is the outstanding symptom. In addition to these symptoms there is muscular weakness and early onset of fatigue, anorexia (lack of appetite), loss of weight and nausea. The gastrointestinal involvement which includes anorexia, indigestion and constipation are usually among the first signs of the development of this disease. In this country the polyneuritis is the most commonly noticed form of the disease owing to the numbers

of chronic alcohol addicts. It is reported that about 20 per cent of these have neuritic manifestations of beriberi.

Riboflavin Deficiency (Ariboflavinosis)

A deficiency of this vitamin results in stoppage or retardation of growth in young animals as well as dermatitis and cataract (opacity of the lens of the eye) in rats and paralysis in chickens. Ariboflavinosis (lack of riboflavin) in human beings is characterized by inflammation of the lips, fissures or cracks in the skin at the corners of the mouth (cheilosis), glossitis (inflammation of the tongue), dermatitis resulting in a greasy eruption of the skin, and a vascularizing keratitis caused by invasion of the cornea of the eye by blood vessels. Ariboflavinosis usually occurs in conjunction with other deficiency diseases (multiple deficiencies), commonly in conjunction with pellagra.

Niacin Deficiency (Pellagra)

The deficiency disease associated with a lack of this vitamin and known as pellagra is characterized by a dermatitis (inflammation of the skin) and stomatitis (inflammation of the mouth) in conjunction with mental depression, gastrointestinal upset and weakness. Pellagra outbreaks tend to occur most frequently among low income groups, probably because of food restrictions. In this country most cases appear in the Southeastern states in the spring.

Vitamin K Deficiency

The principal consequence of vitamin K deficiency is hemorrhage caused by failure of the clotting function of the blood. The hemorrhage may be attributable (1) to inadequate intake of vitamin K, (2) to inadequate absorption which is the result of disease of the gastrointestinal tract and particularly in conditions which interfere with the presence of bile in the intestine, such as obstructive jaundice, or (3) to deficiency in the new-born, as a result of inadequate prenatal intake by the mother. In the new-born, besides

a low intake from food, the normal bacterial flora which synthesize the vitamin in the intestinal tract have not yet developed.

Vitamin D Deficiency (Rickets, Osteomalacia)

The condition produced by vitamin D or calcium deficiency is known as rickets in the young and osteomalacia in the adult. In rickets, bones cease to grow owing to a lack of mineral deposition. As osteomalacia progresses the calcium and phosphorus already present may be withdrawn. The poorly calcified bones are abnormal in shape as well as being small and brittle. Along with this specific abnormality in skeletal structure vitamin D deficiency may increase the incidence of dental caries as well as produce a weak and flabby condition of the muscles.

If untreated, rickets may develop to a degree of severity which produces death, but the mortality rate from this disease has shown a consistent decline in recent years. During the years 1933–1941 the number of deaths from rickets each year in the United States decreased from 339 to 139, a reduction of 60 per cent produced by application of knowledge derived from nutrition research.

Calcium and Phosphorus Deficiency

Lack of calcium or phosphorus in the diet produces profound changes and defects in the skeletal frame-work of the body since these two minerals are the chief components of bone. Adequate amounts of vitamin D are necessary for the proper utilization of calcium and phosphorus but it is obvious that vitamin D alone will not insure against a dietary inadequacy of these minerals. As does vitamin D deficiency, lack of calcium produces rickets in children and osteomalacia in adults. Spasmophilia or infantile tetany is the outstanding feature of calcium deficiency in rickets. Numerous factors may contribute to inadequate calcium utilization: the composition of the diet, the acidity of the gastrointestinal

tract, laxation rate, fat digestion and absorption, and the amount of vitamin D available.

If other components of the diet are supplied in adequate amounts there need be little concern about phosphorus deficiency for this mineral is widely distributed throughout plant and animal tissues.

Ascorbic Acid (Vitamin C) Deficiency (Scurvy)

One of the first signs of vitamin C deficiency is gingivitis or inflammation of the gums, accompanied by loss of weight, pain in the extremities and mild anemia. In typical scurvy resulting from severe deficiency there are muscle and joint pains, hemorrhages in the joints and skin, swelling or edema of the legs, swelling and bleeding of the gums, and anemia. The teeth become loose and may fall out and ulceration of the gums may result from secondary infection. In infants there is swelling and tenderness in the legs and the bones show striking abnormalities.

Iron Deficiency

Nutritional anemia designates the anemia which results from an inadequate intake of iron in the diet. Inasmuch as iron is an essential component of hemoglobin—the red coloring substance of the blood which is essential for the transport of oxygen from the lungs to the tissues and the return to them of the carbon dioxide formed in the tissues—a dietary deficiency of iron prevents the formation of this substance in the body. A history of dietary iron deficiency is one of the main criteria for evaluating the condition of nutritional anemia, since infections, blood loss and other disturbances may also cause anemia. Failure to absorb or utilize iron (lack of copper) will produce the same result. Furthermore, hemoglobin is a protein and a protein deficiency in the diet or a deficiency of amino acids resulting from a dietary intake of poor quality protein which would fail to furnish the essential amino acids necessary for hemoglobin formation would produce anemia.

Life Expectancy and Aging (Geriatrics)

The life span of man has been increased about 15 years in the quarter century since the first world war and about 30 years in the last six decades. The longevity of the American people, as reflected by life insurance statistics, has reached such high levels that the average boy of 16 may expect half a century of life and the same expectation lies before a woman of 21 years. This is in stark contrast to the present average span of life in India, said to be about 25 years. The lives of American people will be greatly changed during the next twenty-five years and white men now 45 years old and white women of 50 years still will be present, with their accumulated experience and wisdom qualifying them to share with those who are now young the task of building the future world. According to the United States Census, the number of people past sixty-five years of age has increased during the last ninety-years from 2.6 per cent to 6.8 per cent of the population. If this trend continues, fifty years hence about fifteen out of every one hundred people will be over sixty-five years old (60).

The initiation of the germ (microbe) theory of disease by Pasteur and others and the development of the sciences of bacteriology and immunology and their application to disease have been great aids in the prolongation of life. The development of new drugs and chemotherapy have contributed further to the control of infectious disease. The sulfa drugs, penicillin, and other equally potent drugs now in the experimental stage, by reducing the loss of life from pneumonia, infected wounds and diseases of many kinds, are contributing to increased life expectancy. Important as these medical factors are, there is no more potent factor in the extension of life than the spectacular and far reaching effects of the practice of the newer principles of nutrition. Today, one can eat to stay young as well as eat to grow slim. The importance of good diet, adequate rest and proper exercise in prolonging life and preserving vigor of body and mind is becoming generally appreciated and practiced.

Studies on the relation of nutrition to the life span of experimental rats have demonstrated the value of healthful physical exercise in later life and the dangers of becoming overweight. Obese rats have shorter life spans than lean rats. Healthy animals survive longer as a result of a reasonable amount of exercise. McCollum has long emphasized the importance of diet in better growth and greater adult vitality, persistence of youthful characteristics and increase in length of life. Sherman has likewise demonstrated that a "good diet" can be made "better" with the nutriments contained in milk. A "better" diet contributes to buoyant health, greater resistance to disease, greater fertility and productivity, and to a longer and more fruitful life.

Improvement of nutrition and reductions in infant mortality and morbidity have resulted since pediatricians (infant and child physicians) have put modern nutrition concepts into practice. The aged can similarly profit if the newer knowledge of nutrition is applied in geriatrics (study of aging). Carlson (60) has summarized

> progressive age changes not as yet shown to be due to specific diseases: gradual tissue desiccation; gradual retardation of cell division, capacity of cell growth and tissue repair; gradual retardation in the rate of tissue oxidation [lowering of the B.M.R.] cellular atrophy, degeneration, increased cell pigmentation and fatty infiltration: gradual decrease in tissue elasticity and degenerative changes in the elastic connective tissue; decreased speed, strength and endurance of skeletal neuromuscular reactions; decreased strength of skeletal muscle; progressive degeneration and atrophy of the nervous system, impaired vision, hearing, attention, memory and mental endurance.

On the basis of present knowledge, the aged should follow a well-balanced diet moderate in amount and protein content but the protein should be of good quality. It should be low in fat and provide liberal amounts of the essential minerals and some bulk. If one wishes to eat to stay young and to add life to years as well as years to life it is well to practice eating, at all ages, well-balanced meals which supply nutriments in the amounts and proportions needed for maintenance and repair of the body tissues.

Chapter Five

NOURISHMENT FROM THE SOIL

Despite the great advances made by man since the dawn of recorded history only several fur bearing animals and a few important plants such as cinchona (quinine), hevea (Para rubber), and abaca or Manila hemp have been domesticated in modern times and none of these are food-producing. Although one is impressed by the almost universal distribution, depending upon soil and climatic conditions, of present day food-producing animals and plants, it has taken place in the past 500 years. Before Columbus sailed westward into the unknown reaches of the Atlantic Ocean none of our food-producing plants or animals was known outside the continental areas of its origin. The centers of origin of our present agricultural products are those regions in which ancient civilizations developed (61).

These regions are few and relatively restricted in scope. On the American continent they are the highlands of Mexico in North America and of Peru in South America and a tropical center in Central America. Parts of the Mediterranean basin in Europe, Asia and Africa, Asia Minor and small areas in central Asia, India and China are centers of origin similar to those of the American continents. In most of these original centers the independent civilizations were built from the standpoint of agriculture, primarily on the basis of several definite foods, although secondary food plants, such as fruits and vegetables, and certain animals were definitely important. For example, in Asia Minor, such cereals as barley and wheat were basic, in India and China, rice, and in the Western Hemisphere, Indian corn was the agricultural crop of the Aztecs of Mexico, whereas potatoes and lima beans were the basic food supply of the ancient Peruvian civilization (62).

Barley is thought to be the first crop grain of the human race. The Egyptians claimed it to be the first cereal used by man and Pliny called it the most ancient cereal. However, it must be remembered that Pliny had no knowledge of the Aztecs of Mexico and their Indian corn. Nevertheless, barley seems to have been the medium of exchange in the earliest recorded times. Wheat is believed to have originated near the shores of the Caspian sea and rice somewhere in tropical Asia. Both were known in China about 3000 B.C. Rye, which is claimed to be oriental in origin, appears to have been cultivated as early as the foregoing cereals. Records of other food producing plants are still less specific as to their earliest use as human food but their sites of origin have been fairly well defined in many cases. Some of the more common food plants are thought to have originated as follows: from Asia, the peach, grape, soybean, citrus fruits and cottonseed; from Asia Minor and the eastern Mediterranean, the fig, date, apricot and olive; from the Caucasian mountain region, the plum, pear and asparagus; from northern Europe, the apple, turnip and cabbage; from southern Europe, celery, lettuce and carrot; and from Africa, spinach, watermelon and cantaloupe. It is evident that these plant foods are all of Old-World origin. Domestic animals such as swine, sheep, goats, ducks, geese, chickens, all breeds of cattle and the horse are all of Eurasian origin.

At first glance it would seem that the New World had little in the way of food-producing plants to offer Columbus upon his arrival. However, some of our most important agricultural products were unknown to the Old World before 1492. Corn has already been mentioned, and although the only cereal crop of American origin, it is today one of the most important. In addition, from North America came pumpkin, huckleberries, cranberries, squash and the kidney bean—and from Central America, peanut, sweet potato, avocado and cocoa. Reportedly, Cortez was the first white man to taste chocolate. It was offered to him, in a golden cup, from the hand of Montezuma, the Aztec Emperor.

South America contributed the "Irish" potato, tomato, pineapple, lima bean and other garden and field beans.

The New World contributed very few domestic animals although one, the turkey, which originally came from Mexico, has become a national symbol in the United States and an important agricultural product. In South America were found the llama and alpaca. Although the North American Indians depended on the bison for their meat supply, particularly in the Western Plains area, these were not considered domesticated in the strict sense of the word. The paucity of domesticated animals or even of the proper animals for domestication may have been a contributing factor to the backward and meager agriculture found in the New World by the early Spanish explorers.

Consider, however, the contrast between the civilized state of man in Asia, Europe, and parts of Africa and the savage state of the native Indians who greeted Christopher Columbus from the shores of America in 1492. Columbus, the first admiral of the "ocean-sea," was a product of 7000 years of civilization which had its vague beginning in Mesopotamia and Egypt around 7000 to 6000 B.C. The savage redskins who viewed with alarm the landing of Columbus and his armored crew on their shores were hunters and nomads. They took their food from the hand of nature, wherever and whenever they could find it. Tribe battled tribe and clan fought clan for the best hunting grounds. The American Indian trod what has proven to be one of the richest agricultural potentials in the world—one of the finest gardens nature had to offer, waiting to be cultivated, waiting for the proper stimulus to yield countless food supplies—yet the red man spent his energy hunting food. In civilization he was living at a time antedating 6000 B.C., for civilization consists of tilling the soil in an area continuously, dwelling in buildings and living under a common rule for the regulation of lives and property.

However, the New World was not devoid of agriculture, nor was it totally lacking in civilization. The Spanish

conquerors who followed Columbus found in Mexico and in Peru advanced Indian cultures established by the Aztecs and Incas. Two of our most potent plant foods known today were being cultivated—maize, or Indian corn, in Mexico, and the potato in Peru. It is interesting to speculate whether these ancient Indian empires were at the dawn or in the evening of their growth and whether, had time been as generous, the Atlantic ocean wider, and Columbus a less persistent and ambitious man, they would have developed the potential of the American continent as did the descendants of the ancient Sumerians of Mesopotamia.

The Development of Agricultural Science

Despite the fact that agriculture was first practiced by our prehistoric ancestors it developed so slowly that at the beginning of the nineteenth century agriculture was little advanced over that of biblical times. Even in America after the Revolutionary War, hand tools and hand labor were the basis of agriculture. Farmers used the wooden plow to turn the soil, they sowed the seed broadcast, they harvested with the scythe, and threshed the grain with flails. With the advent of the machine age modern farming had its birth. Agriculture has advanced more in the past 150 years than in all preceding ages. Agriculture in America and other parts of the world, particularly Europe, changed from subsistence to production. Food became abundant instead of scarce. Farming changed from a livelihood to a profession. Instead of being the main pursuit of all or a majority of the populace, agriculture became the direct business of less than 25 percent of our population.

The United States is today inhabited by people whose ancestors came from other lands. It is an historical fact that a migratory people bring with them seeds and breeding stock to establish their food supply when they take over a new land. The agriculture of the Old World was brought to America by the early settlers. All of our domesticated animals, with the exception of the turkey, came by this route.

It is significant, however, that some of our basic agricultural products which are of native origin had a reintroduction to this country by way of Europe. The Irish potato is the outstanding example of this migration, having been found in South America by the Spaniards, who took it to southern Europe. Eventually the potato made its way to Ireland and at a later date returned to America by way of New England and a group of Irish colonists.

Sometime around the start of the nineteenth century the European and American continents began a change-over from age-old type of agriculture civilization to our modern industrial civilization. Some parts of the world, notably India and China, were more resistant and as a result are only now slowly developing into industrial states. Steam and electricity, coal, steel, and cement transformed the face of the earth in many ways and many places. The sailing ship passed from the work-horse of commerce to the sporting pastime of the wealthy. The steamship converted weeks of ocean travel into days. As on sea, so on land, the steam train replaced the stage coach and where previously it had required weeks and even months under the most hazardous circumstances to span the continent, the trip could be made in a train in a few days in comparative comfort. Kerosene, gas and electricity eventually replaced the tallow candle in turning night into day and cloth and fabrics appeared in abundance as power looms replaced handicraft. As the labors of men and animals were taken over by machines, man's efficiency and productivity showed a tremendous advance.

This great advance in the way of life is nowhere more evident than in man's ability to produce and transport food. Around 1800 the world population was estimated at less than one billion. Today, it is estimated to be over two billion, a more than two-fold increase in population which before the nineteenth century was existing on a very meager food supply. It is well illustrated in history that the food supply must increase with the population. In fact the food

supply must increase first and provide surpluses, otherwise in lean years famine and starvation result. Whether the eventual population of the world is limited by its ability to produce food is a recurring question. A recent estimate of the population which could be fed by the land resources of the United States, if they were employed to the extent of comparable areas in Europe, indicated over 500 million people could be supported, even with the current agricultural practices. It is well known that present agricultural methods do not approach the maximum possible yield of food materials per land unit.

With the advent of machines and industrial civilization, man was not only able to produce surplus food, he could transport it long distances quickly, whereas before, all food was of necessity consumed within a very short distance from the area in which it was produced. We can now sit down to a meal that includes pork from Iowa, beef from Texas, lamb from Montana, potatoes from Maine, vegetables from Florida, fruit from California, milk from New York, butter from Wisconsin, bread made from Kansas wheat and coffee from Brazil. A trip to any modern food store will reveal food stocks that originated not only from all parts of this country, but from all the continents of the earth. This has been made possible as a result of modern methods of production, processing and transportation. The end result has been food abundance and variety throughout the seasons of the year. Furthermore, where formerly the entire population was directly or indirectly engaged in agricultural pursuits, now only a minor fraction is so occupied. Thus, the multitude can be fed by a few. It is no burden on the imagination to visualize that the ancient biblical parable of the twenty loaves and fishes being multiplied by the hand of God to feed the starving legions of the faithful has been accomplished in the twentieth century as the result of industrialization—as the result of man's ability to harness and control sources of energy.

As the result of modern science, and more particularly

the science of chemistry and nutrition, we know today that man cannot live by bread alone. Foods are different. In order to stay healthy a person must eat, not only a sufficient amount of food, but a variety of foods in order to supply the needs of his body. Science has shown that the body is more than a machine. We can stoke a furnace with wood, coal, oil or gas, each or all of these, providing the proper attachments are made, and get heat. We can eat different foods and from them the body will produce heat and energy in the form of work. But, the body also needs materials for growth or building tissues, it needs materials for repair of damaged tissues, and it needs materials for making special compounds or chemicals used in regulating processes inside the body. Science, the science of nutrition, has shown that the body must secure many of these materials "ready formed" or as "finished products" from the food. Furthermore, it has shown that all foods do not contain all of these materials. In order for man to satisfy his first and primary need, he must have sufficient food, but in addition this food must be of the right kind and variety.

The issue of the first world war hung on the question of the food supply. The German submarine campaign in 1915–16 almost succeeded in starving Britain into defeat. The Allies finally forced an armistice, not by defeating the German army, but by a blockade which shut off Germany's outside source of food and raw materials. The same theme was repeated in World War II, with more variations. The Axis countries used food as a weapon of subjugation, and starvation as a means of holding and enslaving large areas of conquered peoples. The Allies used food as a weapon for freedom, making it available wherever they regained territory conquered by the Axis, fulfilling one of the promises known as the "Four Freedoms."

Modern agriculture as practiced in the United States today is the result of a number of outstanding recent developments. They represent the difference between the new and the old. They make the difference between hunger and want,

and abundance. They are: (*a*) soil chemistry and conservation; (*b*) farm machinery; (*c*) plant science; (*d*) animal science; (*e*) research and education; (*f*) farm management. Each has exerted and is exerting such an effective role in our agricultural advancement that they deserve individual treatment.

Soil Conservation

Before 1800, the great French chemist Lavoisier recognized man's heritage from the soil when he said (63):

> Plants derive the materials necessary for their formation from the air which surrounds them, from the water, and in general from the mineral kingdom. Animals feed on plants, or other animals fed by plants, so that the substances composing them are, in the last instance, always drawn from air and from the mineral kingdom. On the other hand, fermentation, putrefaction, and combustion continually restore to the air and the mineral kingdom the principles borrowed from them by plants and animals.

Although earlier workers recognized the importance of soil fertility and its maintenance, the honor properly belongs to Justus von Liebig, the famous German chemist, of being the originator of our modern agricultural science and the father of our present scientific management of the soil. He said (63):

> A rational system of agriculture cannot be formed without the application of scientific principles; for such a system must be based on an exact acquaintance with the means of nutrition of vegetables, and with the influence of soils and action of manure upon them.

As with the opening up of all new countries, the economic progress of our own nation has been marked by the extravagant expenditure of our land and soil capital, which was accumulated in terms of soil fertility in ages past. Selfishly and unwisely we have been spending the capital as well as the interest. This process will in time, if continued, result in disaster. The future progress and prosperity of this country, just as in the past, are directly dependent on the fertility of the soil. As Dr. Jacob Lipman pointed out a

number of years ago at the Second Dearborn Conference of Agriculture (64):

> Soil decadence is usually followed by social and political decadence. . . . We find frequent reference in folk songs and legends to Mother Earth and to her bounty. In partaking of this bounty her children remove from the soil a part of its fertility. This process of removal cannot go on forever without ultimate disaster to the land and to the people dependent upon it. It is not easy to forget the passionate denunciation of Liebig of what he called soil exploitation, nor his plea for soil conservation. He tells us that: 'The sewers of the immense metropolis of the Ancient World engulfed in the course of centuries the prosperity of the Roman peasant, and when the fields of the latter would no longer yield the means of feeding her population, these same sewers devoured the wealth of Sicily, Sardinia, and the fertile lands on the coast of Africa.'

The existence of animals is dependent upon plants which in turn are dependent on the nutriments supplied in the soil. This inter-relationship of the soil, the atmosphere, the plant, and the animal in which the same materials are used over and over again was termed "The Wheel of Life" by E. J. Kraus (65):

> The sum total of elements in the world remains relatively fixed, but there is a more or less constant movement of them from place to place. At any particular location there may be a large accumulation at one time or a decided deficit at another. . . .
>
> Thus, a great cycle or wheel of life is established, constructive processes balancing the destructive. The basic elements are combined, taken apart, and recombined, the green plant being the principal constructive force, nongreen plants and animals the destructive. New individuals come into being and pass away again, but they are all made from the same stock of elemental substances, kept in circulation by the constructive processes of food manufacture and the destructive processes of food utilization, through the medium of green plants, nongreen plants, and animals. Sometimes storage in excess of utilization has resulted in vast accumulations of coal, oil, and similar materials, which when eventually burned or oxidized are also put back into circulation in forms that can be utilized by the green plant [Figure 8].

This great cycle is composed of many lesser cycles of varying complexity. Each individual chemical element required for the growth of green plants has a cycle; there is

WHEEL OF LIFE

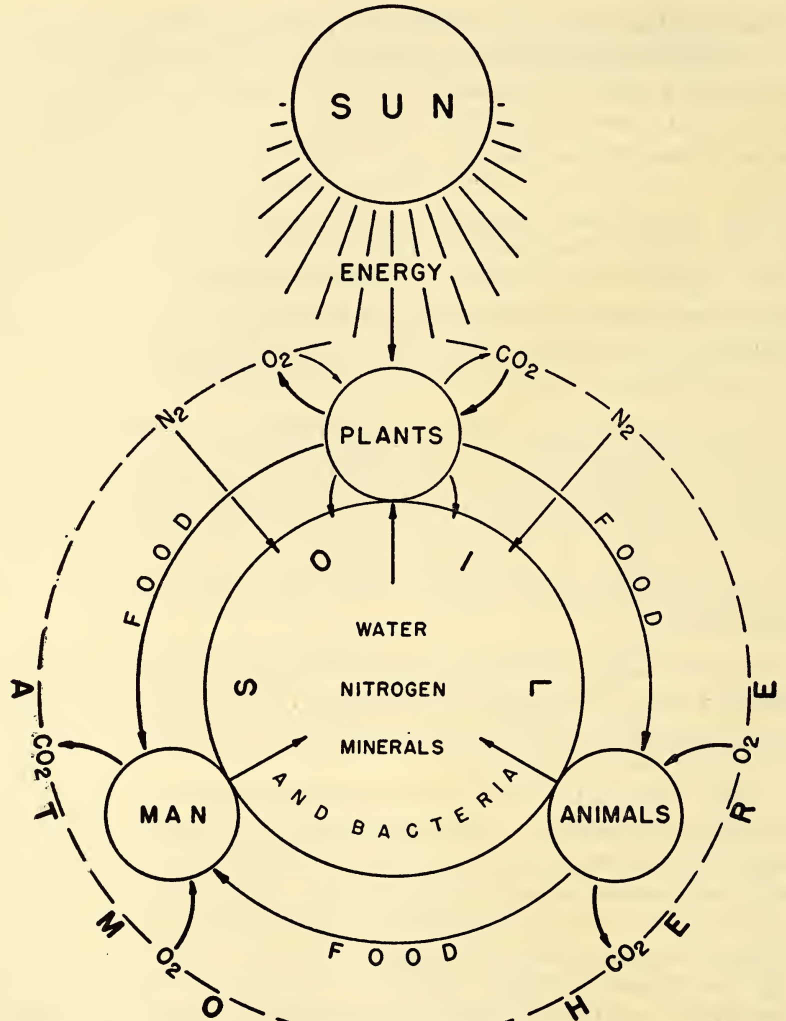


Fig. 8.

a nitrogen cycle, a carbon cycle, a calcium cycle, a phosphorus cycle, a potassium cycle, and so for all of the more than a dozen chemical elements required for the growth and maintenance of plants and animals.

In the nitrogen cycle, for example, nitrogen from the air is captured by bacteria living in the soil or in the root nodules of leguminous plants such as clover and alfalfa and then is converted into soluble nitrogen compounds which the green plants can use. The plants build into their growing structures these various nitrogen compounds, the most complex and important of which are the plant proteins. These proteins and other nitrogen-containing compounds may subsequently be eaten by animals and used to build their own body proteins or they may revert directly to the soil through decomposition of the plant or its products, the leaves, stems or seeds. Eventually, the proteins of the animal body are broken down or reworked into simpler nitrogen compounds which are excreted to the soil. In the soil, bacteria take up the nitrogen-containing products of plant and animal decomposition and break them down into simple nitrogen compounds which can again be reutilized by plants—or they further are decomposed to elemental nitrogen and released to the air. The activity of the soil bacteria is dependent on the presence in the soil of factors such as minerals, moisture, and the organic matter or carbohydrate material which provides energy for their activity.

The carbon cycle is another important and probably more familiar cycle. The combination of carbon with oxygen, carbon dioxide, which is ever present in the atmosphere, is taken up by the green parts of plants. In the plants, the carbon dioxide is combined with water through the action of the sun's rays and chlorophyll, the green coloring material, to form sugar, a basic food. The sugar may be broken down immediately by the plant to furnish energy or it may be used to build a multitude of other compounds which are part of the plant structure (fiber or wood) or be deposited in a storage depot such as the starch of seeds. These substances may then be used by animals as sources of energy or they may find their way directly to the soil where they constitute the bulk of its organic matter or soil humus. The carbon compounds, also, are decomposed and may be reused

from the soil or be eliminated directly into the atmosphere as carbon dioxide.

The fundamental consideration, therefore, in maintaining soil fertility or in the proper scientific management of the soil, and in plant and animal husbandry which are dependent on the soil, is a critical and thorough understanding of "The Wheel of Life." Through a complete comprehension of the individual cycles of the various elements needed for the nutrition of plants and animals that go to make up the great cycle of life it is possible to make the necessary provision for the most economical return of the various elements to the soil or atmosphere, and to provide for their conversion in such a place and manner that they can again become a part of any living organism.

The science of soil management, or conservation, has progressed rapidly in modern times. However, the application of this knowledge has tended to lag behind in some areas and be ignored by certain groups for whom it would prove of greatest benefit. The outstanding example in this country was the formation of the dust bowl in our Southwest and the resultant economic and social upheaval of the residents who migrated westward and gained the sobriquet of "Oakies." Although our soils have been undergoing depletion since we first began to use them, no united national effort or concern ever arose to combat this evil until the recent disasters in which many acres of our best top soil were washed into the sea by floods or blown away by winds. Under the pressure of these national catastrophes, which resulted from our own mismanagement of the soil, our federal government has inaugurated extensive reforestation and soil conservation programs.

Chemical elements may also occur in the soil in excessive amounts. Frequently water and soils are found to have salt, sulfur compounds, alkali, fluorine or selenium in such concentrations that they are unusable for their customary purposes. Various therapeutic values have been ascribed to the internal or external application of the water from

some of the wells in these areas but their value for general purposes is destroyed. From contaminated water and soils it is possible for toxic amounts of particular elements to be transmitted to animals, including human beings, by plants grown in the area. The mottled enamel of the teeth of people who have received relatively large amounts of fluorine in their water supply is well known.

The modern developments which will do most to retain and rebuild the fertility of our soils have been crop rotation, green manuring, the return of animal manure and crop residues to the land, the application of commercial fertilizers, and finally, the control and prevention of erosion. It is a truism that nutrition begins with the soil. Of course, we have long realized that the fertility of Mother Earth controls the production of our food supply, but only recently has recognition been given to the profound influence the composition of the soil may exert on the health and lives of the plants and animals living on it. So far, qualitative control of the soil has been concerned, mainly, with the mineral elements which are essential to the growth and health of plants and animals, including man.

The extreme cases of mineral deficiencies which have been traced directly to the soil have dealt with iodine, iron, copper, cobalt, and phosphorus. Most people have heard of the "goiter belts" which exist in the United States and in other parts of the world. In the United States the goiter region extends around the Great Lakes and the north central plains section. Domestic animals in these goiter regions are particularly susceptible to reproductive failure owing to lack of iodine. Before the introduction of iodized salt, great economic losses were experienced by the farmers through the high percentage of stillbirths among their cattle, horses, sheep and swine. Even if the young were born alive, many were so abnormal that they lived only a short time.

Certain soils in this country, particularly in Florida, have been shown to lack iron. A large percentage of the children in this area had anemia because the vegetables, especially

the green leafy varieties which ordinarily are depended upon to furnish our food supply of iron, lacked this mineral because of the soil deficiency. In certain European soils a lack of copper has produced disease in the animals eating the plants grown on them. Large numbers of animals have been lost each year in Australia and New Zealand from a wasting disease, characterized by an anemic condition, which was recently traced to a deficiency of cobalt in the soil. Soils deficient in cobalt also have been found in northern Michigan and other areas in this country. As little as two pounds of cobaltous salt per acre will, through the increased cobalt content of the plants, not only prevent such sickness in animals but cure those already ill from lack of cobalt. Probably the most widely occurring mineral deficiency traceable to the soil is a lack of phosphorus. Emaciation, perverted appetite, which is evidenced by "bone chewing," infertility and rickets are the outstanding symptoms of this deficiency.

For every extreme case of deficiency disease there may be hundreds of borderline cases which, although not manifesting themselves in the form of disease, do prevent the attainment of maximum growth and health. This latter problem has been studied much more thoroughly with regard to the nutritive requirements of plants and animals than to those of man. This statement applies to the whole field of nutrition. We know much more about the proper feeding of our farm animals and the right type of soil fertilizers for our food plants than we do about feeding ourselves.

It has long been known that the continuous cropping of one particular type of food plant on the same soil eventually depletes the soil and lowers the yield. Modern methods of soil management all are designed to promote the highest yield of food from the land and retain or enhance its fertility. Different crops have different requirements and one crop may replace in the soil some of the materials most needed by another plant. In any area, crops should be selected which promise the greatest insurance against loss from

bad weather or low prices and can be planted in succession so that depletion of the soil is kept at a minimum. Although scientific rotation reduces exhaustion of the soil it does lead to reduced yields unless manure or fertilizers are also used. Apart from fertility, freedom from weeds and parasites is promoted by judicious order of planting.

The modern farmer need not be sold on the benefits of using fertilizer materials. It has been stated (66) that over 20 per cent of the total crop production in this country arises from the use of fertilizer and in 1943 over 11,000,000 tons were used in the United States. In 1939, estimates from large groups of farmers showed that they received an additional crop value of over $3.60 for every dollar spent on fertilizer. On the same basis, they received over $5.00 at the 1943 price level. A crop producer may select commercial fertilizer on the basis of any special need of soil, crop or climate but the principal plant foods supplied are nitrogen, phosphorus and potassium. These, together with calcium in the form of limestone or lime, farm manure (animal residues) and green manures (sod or cover crops which are plowed back into the soil) form the basis of present fertilization methods.

With the development of the science of nutrition, the concept of soil fertility is changing. The soil may be deficient in elements other than nitrogen, phosphorus, potassium, and calcium—the minerals which are most effective in increasing crop yield. Other elements such as iron, cobalt, copper and iodine may have little effect on crop yield, but their absence in the plant may have a profound influence on the animals which depend on these plants for food. But even more than this is involved in the cycle of plant and animal life, for studies of such trace elements as zinc, boron, and manganese, as well as the more plentiful magnesium, have shown their relation to certain plant diseases. Such conditions as mottling in vegetables and "crack stem" in celery have been traced to deficiencies of manganese and boron, respectively.

The ultimate goal of agriculture is the production of food

in sufficient quantity and quality to satisfy the bodily needs of the people of the earth. The fundamental and primary tool of the agriculturist in this food producing process is the soil. The condition and quality of this tool (the soil) governs the quantity and quality of the food it produces. It is possible to reduce the human being to a very simple equation in terms of the soil. It is no exaggeration that if a young chemist should submit his best girl friend to a chemical analysis he would find the ingredients of her "sugar and spice and everything nice" could be purchased at the corner drugstore for less than a dollar. Dr. T. E. Lawson (67) has expressed this idea in more specific chemical terms in stating that if we analyzed an average adult man, we would find:

Enough water to fill a 10-gallon keg
Enough fat for seven bars of soap
Carbon for 9,000 lead pencils
Phosphorus to make 220 match heads
Magnesium for 1 dose of salts
Iron to make one medium-sized nail
Sufficient lime to whitewash a chicken-coop
Sulphur enough to rid one dog of fleas.

The human body is about five per cent minerals (ash), originally derived from the soil (68). On this basis, an adult man weighing 154 pounds would contain nearly eight pounds of soil elements. If any one of these dozen or more soil minerals were missing, life would not be possible. The body contains approximately two and a half pounds of calcium, about one and a half pounds of phosphorus, a little over one-half pound of potassium, approximately one pound of table salt, about five ounces of sulfur, over one ounce of magnesium, and less than one ounce of iron. In addition, the body contains elements such as copper, zinc, manganese, cobalt, iodine, and fluorine, which are essential to life, but are present in such small quantities that they are designated "trace elements." All, however, were originally derived from the soil through the medium of food. Lack or deficiency in any one or more of these products of the mineral

kingdom results in ill health and, eventually, in disease and perhaps death.

For years the primary focus of both agricultural research and production has been on tons per acre, but today this is not enough. The yield per acre must be evaluated in terms of quality; we must measure our production in terms of human body nutriments per acre. As aptly stated by Professor Maynard (69) of Cornell University:

> With the development of the newer knowledge of proteins, minerals, and vitamins, the dietary deficiencies resulting from modern food processing and dietary habits were recognized. A large increase in production and consumption of vegetables and fruits resulted. In this development the goal has been increased yields and market quality. Varieties were selected for high yields, disease, drought, cold or heat resistance. Yields were increased by fertilization and other cultural practices. Ability to withstand shipment to market and to appear attractive to the consumer were held in view from seedtime to harvest. These things are important, but in all of these developments comparatively little attention has been given to the real reason why protective foods are needed—namely, the nutrients in which the diet is otherwise deficient. We need a consideration of yields of nutrients as well as of tons or bushels per acre. Nutritive value must be kept in mind in production, processing, storage, marketing, and in home preparation. Market quality is important but it is not enough. Nutritional quality should come first.

Farm Machinery

The modern farm exemplifies our machine age in the quantity and variety of machines used to perform the different farm operations. The hand plow has been displaced by sulky or gang plows (which turn two or more furrows at one time). In many instances, depending on the soil, the disc plow may be used. Various seeders, planters, cultivators, and reapers have been designed and are used to facilitate man's tillage and relieve him of much arduous labor. Although the horse is still a primary source of farm power, particularly on small farms, the tractor has become the primary power unit in our present agricultural production. Likewise, the truck has supplanted the horse in transportation of the crops to market. The combination harvester and thresh-

ing machine for grains has been a most important labor saving development in farm machinery. Electricity, a miracle of the twentieth century, is gradually relieving the farmer and his wife of many of the monotonous chores which formerly made life on the farm drudgery.

Plant Science

Through scientific plant breeding and culture we have available today varieties of cereals, fruits and vegetables which in yield and taste would be the wonder of the ancient world. Although no new food plants have been discovered, the improvements through cross-breeding and selection have made many of our present day varieties unrecognizable in terms of their early progenitors. Hybrid corn, Kanred wheat, Idaho potatoes, seedless grapefruit, the Bartlett pear, the Elberta peach, the Delicious apple, the Concord grape, and the beefsteak tomato are all examples of scientific selection and breeding in the improvement of our food producing plants.

Probably even more important, from the standpoint of food production, have been the development of disease-resistant plants and the control measures introduced to fight and eliminate insects and plant pests. Sprays and dusts have been developed with precise abilities to control sucking and chewing insects. The older, poisonous compounds, which usually contained arsenic and lead, are being supplemented by newer products such as pyrethrum and rotenone. These agents are equally or more effective in most cases and do not have the hazards which accompany lead, arsenic, and nicotine combinations. Without the modern insecticides, fungicides and scientific pest-control measures, the modern farmer would lose a large portion of his production.

Animal Science

Progress in animal husbandry has paralleled very closely that in plant husbandry. Through breeding and selection we have domestic animals which are unequalled in pro-

ductiveness, dairy cows producing over 30,000 pounds of milk in a year and hens laying over 300 eggs in the same period. Unfortunately, not all of our animals have such capacities, but there is no reason why they eventually cannot have. Animal science has also improved the quality of butter, eggs and other foods. Control of some and eradication of other animal pests and diseases have been outstanding developments, important from the standpoint of human welfare. Tuberculosis, undulant fever, trichinosis and hoof and mouth disease are all deadly diseases which may be transmitted to human beings by domestic animals.

Research, Education and Farm Management

The farmer of today has available, free of charge, the best practicable knowledge obtainable. The federal government and the states maintain large experiment stations and farms whose sole purpose is to obtain information helpful to the farmer. Agriculture in our modern world is a business as well as a livelihood. Our direct food production is in the hands of less than twenty-five per cent of our total population and the trend is still downward, therefore, the modern farm is a business enterprise which not only provides for the farmer and his family but must produce a surplus to feed the non-farm population. The prosperity of the two groups is interdependent. If the farmer fails, not only he and his family suffer, but the population as a whole will suffer. As with any business, efficient management is essential. Unfortunately, the farms of our country have not had the efficient management bestowed upon our other industries. This is not a criticism of the farmer, but points rather to a lack of appreciation by the populace as a whole, of the importance of food production to their health and welfare.

Agriculture Planned for Nutrition

When primary foods such as wheat and corn are fed to hogs they are converted into body substances of the animal and then into meat and lard. By this route we have wheat

and corn as secondary foods which are consumed indirectly by man. Efficiency in the use of primary or secondary foods depends upon a variety of factors. It is known that animal species are efficient in different degrees. For a given species the efficiency varies with the breed and age of the animal and the time it is slaughtered. The younger the animal (within limits) at the time of slaughter, the more efficient is the conversion. For example, the conversion is more efficient in the case of hogs if slaughtered at 150 pounds than if allowed to grow to 300 pounds; the efficiency is greater if beeves are slaughtered at 15 or 18 months than at four years old.

Much of the foodstuffs used in feeding hogs are primary foods and are suitable for direct human consumption, such as the cereal grains and skimmed milk. Cattle and sheep, on the other hand, may be produced upon fodder materials which are entirely unsuitable for human consumption and to a large extent are produced on grazing lands unsuited for other purposes. Although less efficient in the percentage of energy of the feed that is recovered in the form of protein and fat, cattle may be produced without feeding materials which are suitable as primary foods. If cattle are produced by stall feeding upon grains that might be consumed directly by man, such a practice is an economic waste. Dairying is a more efficient energy converter than beef production and is about equal to the hog in this respect. The cow is more efficient in converting nitrogenous vegetable substances of inferior value into animal protein of superior value. Cows not only furnish us with milk and veal but when they are no longer useful as dairy animals they may be used as beef.

In times of war, with accompanying shortages in food and manpower, it is necessary to conserve the primary foods for direct human consumption and if secondary foods are produced, to use the most efficient animal converter of energy and nitrogenous foodstuffs for human consumption. With the increased demands it is essential that agriculture be adjusted to produce the maximum of foods, of the highest nutritive value, at the least expenditure of the primary foods

and of labor. Dietary habits must be adjusted through education to make the maximum use of the foods that are provided for man.

Some idea of the relative productiveness of food sources may be gained from the accompanying table, calculated by Dr. John D. Black (70) from estimated values published by the United States Bureau of Agricultural Economics (71). As such, they are only rough averages applied to production figures of the country's overall agriculture and are not representative of any one food producing area. However, they do indicate how the productiveness of part of our soil may be increased in terms of nutritive values without any change in the area of cultivation. In Table 4 the production of

TABLE 4

RELATIVE NUTRITIVE VALUE OF DIFFERENT FOOD SOURCES PER LAND UNIT*

	Energy	Protein	Minerals‡	Vitamins§
Soybean—whole, edible	100	100	100	100
Wheat—whole, flour	73	26	38	47
Milk—whole	23	11†	6	19
Eggs	9	8†	2	11
Hogs	32	5†	1	21
All beef cattle	3	2†	0.3	3

* All values are calculated on the basis of 100 percent provided by soybeans

† While a unit of land produces less protein in animal sources the protein is superior to that of vegetables.

‡ The three minerals, calcium, iron and phosphorus, combined by dividing the amounts produced per acre and per day by the amounts consumed in a year in a diet providing adequate amounts. (Recommended Dietary Allowance except for phosphorus.) The unit in the table is therefore a year's supply of these minerals for one person.

§ The following vitamins combined on the same basis as the minerals: Vitamin A, thiamine, ascorbic acid, riboflavin and niacin.

energy, protein, minerals and vitamins by soybeans from a given unit of land when grown for human food is taken as 100. If the same land area were sown in wheat only 73 per cent as much energy would be produced in terms of human food value. The values are even lower for proteins, minerals and vitamins, 26, 38 and 47 per cent respectively. If the

same amount of land is used for dairying or beef production the nutriment yield is very much lower. In terms of food energy production the hog is the most efficient of the animals but two-thirds of the energy production of the land is lost if hogs are raised instead of soybeans. In the production of protein and minerals the dairy cow is the most efficient of the animals and about equal to swine in the production of vitamins. However this does not mean that we should, or can, use all our agricultural land wealth for the production of soybeans or other cereals. We do not live on soybeans or wheat alone. Cows and beef animals can utilize grasslands which are unsuitable for producing the primary foods. It does mean that in a balanced agriculture the land must be partitioned for the production of primary and secondary foods in such a manner as to yield the maximum amount of food nutriments suitable for human beings.

Kellogg (72) stated that:

> Now that modern technology has revolutionized our food habits it is up to modern science to check the nutritional quality of our foods all the way along the line from the soil to the people. It has now become common knowledge that processed foods, like white flour, polished rice, refined sugar, and badly cooked vegetables, are lacking in the essential minerals and vitamins that our less finicky ancestors got in the natural foods. But it is not always realized that we are more numerous than they were and must use our soils more intensively, with pronounced effects on the resulting agricultural products.

Chapter Six

THE SUBSTANCE OF LIFE

Planning for nutrition is today a scientific procedure. When the First World War broke out, common belief was that any combination of foods that furnished enough energy, protein, and minerals such as calcium for bones and iron for the hemoglobin of the blood, would meet the requirements of good nutrition. By World War II chemists knew that there are more than forty specific materials which are involved in properly nourishing the body and today we are much closer to being able to write a complete list of the substances required by the human body and to prescribe diets that will meet the nutritional requirements of people of any age, working under all kinds of conditions, and living in various climates. In addition to knowing so many factors that are necessary for health, we have information on the circumstances which may alter a person's requirements. Although not complete, we do have sufficient knowledge so that, if applied, it would improve the nutritional status of the nation and build a stronger race for the future.

Fuel for the Body

Physicists believe that there is in the universe a specific amount of energy and that it cannot be increased or decreased. All of the energy of our one small planet is derived from the sun, and the radiant energy of sunlight continues to furnish warmth to both animals and plants. In addition, sunlight is necessary for the growth of all green plants. The earth, with its vegetation and animal life, represents a warehouse of potential energy which can be transformed from one form into another. Energy is the ability to do work. Nature's method of releasing potential energy for the animal body to

carry on its internal and external activities (work) is *oxidation*, or burning, of suitable food materials. The energy requirements of the body may be supplied by any of the three fuel components of food: carbohydrates (sugars and starches), fats and protein. The energy value of food is expressed in heat units (calories), however, the body is not a heat engine. In a heat engine, heat is the source of work, whereas in the body heat is the result of the internal and external work done. For this reason heat units, *calories*, are used as the quantitative measure of energy.

Even lying quietly in bed, work is being performed to keep the heart beating and to continue, uninterrupted, the many metabolic processes essential to maintaining life. At rest, following a fasting period of twelve or fifteen hours, the human body is burning only the amount of fuel required to maintain body functions and to this minimum rate of heat production the term *basal metabolic rate* (B.M.R.) has been applied. In the process of oxidation the carbon and hydrogen of fuels are united with oxygen to form carbon dioxide and water. In the animal, the carbon dioxide from oxidation of food is emitted from the lungs, which also take into the body the air containing the oxygen necessary for the burning process. The machines with which basal metabolic rate is determined merely measure the amount of oxygen used by the body in a given time. Knowing the amount of oxygen used, calculation of the heat (calories), or energy, released during the oxidation is a simple procedure. Since the heat is lost from the surface (skin) of the body, the amount given off is proportional to the amount of surface. Small bodies have large surface areas in relation to their weight. Infants and children need more calories per unit of body weight than do their mothers and fathers. In fact, an infant needs approximately twice the number of calories per unit of weight as does his mother, because he is so much smaller in size and therefore has so much more surface area per pound of body weight. For this reason, basal metabolic rates are usually calculated in percentages of standards based

on the person's age, height, and weight. Clinically, the B.M.R. is a valuable indication or confirmative aid in diagnosis but the standards are not closely defined, since variations of 25 per cent (from -10 to $+15$), or more, must be considered to be within the normal range.

Oxidation processes provide the energy expended by the body; whether the energy is employed to maintain body temperature, to support muscular activity, or to convert food substance into suitable form and incorporate it into the body tissues as increment or replacement. Mental effort requires no measurable quantity of energy but emotional strains or reactions, on the other hand, cause greater muscular tension and therefore enlarged energy exchange. The amount of energy (calories) required to maintain the normal temperature of the body varies with environment. In the intense cold of arctic regions this demand is extremely high. Under conditions in which the temperature of the environment is nearer the normal body temperature, the heat requirement is proportionately decreased. Under conditions in which the environmental temperature is greater than that of the body, the heat lost from the body by radiation is reduced and sweat from the glands in the skin and the moisture from the respiratory passages must be evaporated to remove the excess. In this process the heat needed to change the liquid moisture into vapor is drawn from the body and removed as the vapor is absorbed by the surrounding air. Since the ease with which the surrounding atmosphere will take up moisture is dependent upon its degree of saturation and the amounts of surface and air in contact, low relative humidity facilitates heat removal, as do reduced amounts of clothing and movement of the surrounding air.

Climatic conditions influence man's rate of growth, speed of development, and resistance to infection. The heat of the tropics lulls people into a passive complacency and saps their vitality; residents of colder climates are driven onward into restless activity since natural conditions permit their tissue fires to burn more brightly. Everyone needs enough

calories to meet the energy cost of his various activities. If sufficient calories are not provided, a loss in body weight will result because the energy cost of living cannot be ignored and therefore the body consumes its own tissues in order to furnish the needed energy. In a cold climate more calories are required daily because heat losses to the environment are greater, depending on how well body heat is conserved through the use of warm clothing and heated quarters. In warmer climates people dress to facilitate greater loss of heat from the body to the environment. Environmental temperatures seem to regulate the very growth-rate and vitality of all living things.

The amounts and kinds of food required for satisfactory nutrition are not alone determined by the body's need for fuel to provide heat. Regardless of the fuel requirement for maintaining body temperature, food must supply the energy for all body activities and should contain the needed amounts of all necessary nutriments. In using food substances to meet other requirements, such as those for minerals, vitamins and amino acids, excess amounts of heat may be produced which must be removed from the surface of the body. Some foods contain higher proportional amounts of one kind of fuel than others, but the amount of energy that any food will yield in the body in the form of work is practically the same whether burned inside or outside the body. Pure proteins and carbohydrates have the same physiologic fuel value per pound in the body, but pure fat is a richer source of energy, having two and one-fourth times as high an energy value per unit weight. Therefore, the more fat a food contains the higher its energy value in relation to its weight.

Carbohydrate in the form of sugars is the most easily digested of the three body fuels. It is not only the most easily available, since it is oxidized directly into water and carbon dioxide with the aid of B vitamins and certain minerals, but also it is the most economical source of energy. Other carbohydrates, principally starches, are converted to

simple sugars as the first process in their digestion. In addition to providing energy carbohydrates are necessary for the complete metabolism of fats.

Fat, as the richest source of energy in the body, plays an important role in energy metabolism. Besides its fuel value it is the conveyor of essential unsaturated fatty acids, the fat-soluble vitamins and other organic substances which are essential aids to metabolism in general and of proteins especially. There is convincing evidence that thiamin plays a role in the synthesis of fat from carbohydrate, in the body. Increasing the proportion of fat in relation to carbohydrate in the diet tends to reduce the thiamin requirement.

Protein taken into the body is split during digestion into amino acids. The individual amino acids are absorbed, and in the body these nitrogenous products may be partially burned to provide energy. Of these incompletely burned substances, a part may be excreted in the urine and others may be converted into carbohydrates or body proteins, depending upon the availability of food and the current needs of the organism. The amount of protein constituents used to build body tissues may be influenced by the total calories consumed and by the amounts furnished as fat and carbohydrate. It is more economical, metabolically, to provide fats and carbohydrates to take care of energy needs and to spare the protein for tissue construction. Proteins are the most costly of all food.

Sherman and Lanford (73) have summarized the fate of the carbohydrates, fat and protein in foods during metabolism thus:

> Carbohydrates may be burned to yield energy: (a) for external muscular work, (b) for internal activity, (c) for heat; stored as glycogen; changed into fat.
>
> Fat may be burned to yield energy: (a) for external muscular work, (b) for internal activity, (c) for heat; stored as fat; used in synthesis of tissue lipids; possibly to some extent changed into carbohydrate.
>
> Protein may be used in building or repair (upkeep) of protein tissue; used in synthesis of certain hormones, enzymes, and other body regulators; deaminized and burned to yield energy, (a) for external muscular work,

(b) for internal activity, (c) for heat; changed into carbohydrate; changed into fat (possibly through carbohydrate).

Recently, as a part of the activities of the Committee on Nutrition of Industrial Workers of the National Research Council, a revaluation of the energy requirement of men working in the logging industry confirmed former estimates that these men may need as much as 6,000 calories per day. The energy requirements for other types of industrial activities are being given special consideration and study as a part of the national effort to assure food enough for men and women working in the war industries. Measurements of the energy requirement of various types of occupations as summarized by the late Mary Swartz Rose (74) are given in Table 5.

TABLE 5
DAILY ENERGY REQUIREMENT ACCORDING TO OCCUPATION

Type of occupation	Total calories per day		Calories per kilogram per day	
	Men	Women	Men	Women
At rest but sitting most of day	2000–2,300	1,600–1,800	31	30
Work chiefly done sitting	2200–2,800	2,000–2,200	36	38
Work chiefly done standing or walking	2,700–3,000	2,200–2,500	41	42
Work developing muscular strength	3,000–3,500	2,500–3,000	46	49
Work requiring very strong muscles	4,000–6,000	....	71	

Carbohydrates

The two important classes of carbohydrates are starches and sugars. The body can use either, since before being absorbed into the body, carbohydrates are converted into

simple sugars during digestion. During the last century the annual, per capita, refined sugar consumption has increased from ten pounds to over 110 pounds (75). There is a considerable amount of positive evidence to indicate that this refined sugar consumption is much too high. The rationing of sugar, with the consequent reduction in the per capita intake was a positive health measure.

Carbohydrates are found chiefly in fruits, vegetables and cereals. Granulated sugar and cornstarch are examples of pure carbohydrates which have been stripped of the vitamins and minerals that are so essential in the metabolism of these substances in the body and are found with the natural carbohydrates in fruits, grains, milk and honey. Chemically, beet and cane sugar are the same. Simple sugars such as glucose (dextrose), levulose and galactose differ, though all may be used by the body. Glucose is the most common of all the simple sugars and is the one that circulates in the blood stream. Levulose is found in fruits and honey and galactose and glucose are formed when milk sugar (lactose) is digested.

The material commonly referred to as bulk, roughage, or fiber is also carbohydrate, but its chemical structure is "complex." These complex carbohydrates (lignin, cellulose, hemicellulose) are frequently designated as "unavailable" carbohydrate to distinguish them from the starches and sugars in food, which are "available" for use by the body. The term "unavailable," while adequate for all practical purposes, is inaccurate since some of the complex carbohydrates (cellulose, hemicellulose) of young plant fiber can be broken down in the intestinal tract.

Fats

When fats are mentioned, many people think of butter, shortening and fat meat, in other words, "visible fats." In addition to these fats, there are also "invisible fats," such as the fats contained in meat, eggs, cheese and milk. These unseen fats compose slightly more than half of the estimated

consumption of fats in the United States. Both kinds of fat are used as energy fuel by the body. It has been estimated by the Food and Nutrition Board of the National Research Council that the annual prewar consumption of fat was 44 pounds per capita; in 1943 it was 51 pounds (104).

One of the most important functions of fat in the diet is transporting fat-soluble vitamins. Such foods as butter and egg yolk supply significant amounts of vitamins A and D. In addition, fats are unique in their ability to increase the richness and attractiveness of our food. The preference for fried foods comes from their enhanced flavor and eye-appeal resulting from the use of fat in frying. Finally, a certain amount of fat in the diet is necessary to supply the "essential fatty acids." Although several unsaturated fatty acids constitute this group and may be interchangeable in their functions, only one, linoleic acid, is essential. On diets devoid or low in fat, rats develop a scaly skin and caudal necrosis (degeneration of the tail), cease to grow normally, show kidney lesions and hematuria (bloody urine) and eventually die. In human beings, particularly infants, certain eczemas seem to result from a deficiency of the unsaturated fatty acids. The "essential fatty acids" are necessary parts of the structure of the cells of organs and tissues. Linoleic acid appears to be especially important to the health of the skin and if contained in the diet in adequate amounts will exert a "sparing action," or lessen the need, for certain vitamins which affect the skin.

Protein

The importance of adequate mineral and vitamin intakes is frequently stressed in current teaching in connection with the nutrition program. Equally worthy of consideration, but less often emphasized, is the need of an adequate daily protein allowance. Dietary protein deficiency seldom leads to characteristic clinical symptoms, and it is just this quality which makes protein undernutrition rather more insidious and difficult to diagnose, without the aid of elaborate

chemical studies, than other deficiency disorders. A dramatic demonstration of the results of protein insufficiency occurred during World War I, when nutritional edema affected wide areas of impoverished Europe. This condition was the result of lowered serum protein concentration, brought about by the failure of the poor diets to furnish enough protein of good quality. In 1936 Dodd and Minot (76) published studies on 500 children in the South, which showed that a chronic low-grade deficiency in serum proteins is common among children in the lower economic groups of that region. This deficiency may become exaggerated in the presence of infection. There is convincing evidence (24) indicating that a deficiency of dietary protein occurs in about half of the clinic and private maternity patients. When put on a higher protein diet, conditions of edema, sallow, pasty complexion and puffiness of the face clear up.

In the past the protein requirement of man has been determined by nitrogen requirement, but with more knowledge of the composition and nutritive behavior of the different proteins, it has become evident that the nutritive value of a protein resides in its component parts, the individual amino acids. The variety of proteins in body tissues and fluids represent numerous combinations of these amino acids, varying in number and quantity. Likewise, in the proteins of the various animal and vegetable foodstuffs which compose our dietaries the number and amounts of individual amino acids vary widely. Some progress also has been made in determining the role of the individual amino acids in the nutrition of man. Research in this field has been along four lines of approach: (*a*) determination of which amino acids are necessary or "essential" to the proper nourishment of human beings; (*b*) the amounts of the essential amino acids required by the body; (*c*) the function of the individual amino acids in nutrition; (*d*) the amino acids in foods.

Experiments on which amino acids are essential have been made by Professor W. C. Rose, of the University of

Illinois, who fed to rats synthetic experimental diets containing purified, individual amino acids as the sole source of protein. His experiments have shown that lysine, arginine, histidine, leucine, isoleucine, valine, methionine, tryptophane, phenylalanine and threonine are needed in the diet of the albino rat to support normal *growth* (77). Dr. H. H. Mitchell (78) has extended this type of study to an investigation of the amino acid needs for *maintenance* of adult rats and has shown that this requirement is somewhat less fastidious, in involving only the following amino acids: threonine, isoleucine, tryptophane, valine, tryosine or phenylalanine, methionine, and leucine or norleucine.

More recently, Dr. L. Emmett Holt, Jr., and his associates at The Johns Hopkins University have determined amino acid requirements by direct observations on man rather than by deductions based on animal experiments (79). Different casein hydrolysates, (chemical combinations with water), each lacking one essential amino acid, were fed at different times to determine the effect of this mixture on the nitrogen balance, followed by a study of the effect when the missing amino acid was restored to the mixture. Holt's studies are in agreement with those reported earlier on rats and constitute direct evidence that the human species probably requires the same amino acids essential for rats. Professor Rose (80) is now actively engaged in determining the amino acids which are essential in human nutrition and has obtained results similar to those reported by Holt. The basic diets used by the two groups differ; the results, however, have been similar and together they establish that 8 of the 10 amino acids essential for animals, are also indispensable for man. Arginine in the amounts fed was not essential for maintaining nitrogen equilibrium in the human adult but was necessary for maximum weight increase in animals during growth. In his most recent studies Rose has found evidence that histidine, also, is not required for maintenance of nitrogen equilibrium in adult men. This does not necessarily mean that these are not dietary essentials for man.

The known number of amino acids may be enlarged in the future and it is certain that experimental work now in progress will expand greatly our information concerning the 23 amino acids which now are known. From the evidence available at this time these 23 amino acids have been classified by Professor Howard B. Lewis (81) of the University of Michigan:

Indispensable: Leucine, isoleucine, threonine, histidine, phenylalanine, lysine, tryptophane, methionine, valine.

Indispensable for maximum weight increases but not necessary for fairly satisfactory growth: Arginine

Dispensable: Norleucine, aspartic acid, glutamic acid, hydroxyglutamic acid, proline, hydroxyproline, citrulline, tryosine, cystine, glycine, alanine, serine, hydroxylysine.

While data for the entire population of the United States indicate one-quarter of the protein in the American diet comes from meat, poultry and fish and another one-quarter comes from eggs, milk and cheese, it is probable that these average values would apply to the diets of very few persons. Some people obtain by far the largest portion of their protein from animal sources, eating very few of the vegetables and legumes (such as peas and peanuts) which have considerable amounts of protein. Our so-called vegetarians, in addition to their vegetable proteins, eat animal protein in the form of eggs and milk products. The infant gets all of his protein from milk in the first few months. Today, the problem of protein adequacy has become a problem of adequate amounts of the essential amino acids and the replacement of one protein food in the diet by another has become a problem of replacing essential amino acids of one food and maintaining the level of amino acid intake by substituting foods which provide equivalent amounts.

Few attempts have been made to determine the amino acid distribution in common foods and thus approach the problem of the amounts of the essential amino acids which must be furnished the body *in food*. Dr. Eliot F. Beach and his associates at the Research Laboratory of the Children's

Fund of Michigan (82) analyzed human and cow's milk and published a comparison of their contents of six amino acids in 1941. The same group first determined the amounts of 10 amino acids in 17 meats which are commonly used in American homes (83, 84). Because of the growing recognition of the importance of the amino acids in the nutrition of human beings, the data from these studies are shown in Table 6. For comparison, the amino acid content of flour, which is a common source of vegetable protein, is included.

TABLE 6

AMINO ACIDS IN MEATS, ORGANS, MILK, FLOUR AND EGG

Values in per cent of fresh weight

Muscles	Arginine	Histidine	Lysine	Phenylalanine	Tyrosine	Tryptophane	Serine	Threonine	Cystine	Methionine
Beef	1.47	0.48	1.71	1.05	0.92	0.28	1.14	0.96	0.28	0.66
Veal	1.40	0.44	1.78	0.83	0.91	0.25	1.12	0.95	0.25	0.68
Lamb	1.38	0.42	1.59	0.83	0.89	0.25	1.14	0.98	0.25	0.59
Pork	1.40	0.46	1.82	0.83	0.94	0.28	0.96	0.96	0.24	0.68
Chicken (light)	2.11	0.73	2.60	1.19	1.32	0.40	1.44	1.44	0.40	1.04
Chicken (dark)	1.78.	0.58	2.12	1.18	1.10	0.31	1.39	1.15	0.31	0.92
Frog Legs	1.08	0.35	1.31	0.77	0.77	0.23	1.05	0.80	0.21	0.52
Salmon	1.49	0.54	2.08	1.04	1.02	0.33	0.92	0.97	0.28	0.88
Codfish	1.41	0.46	1.87	0.97	1.02	0.28	1.11	1.02	0.28	0.83
Shrimp	1.46	0.39	1.87	1.06	1.06	0.28	0.90	0.88	0.25	0.76
Beef Organs										
Heart	1.22	0.35	1.17	0.84	0.72	0.23	0.98	0.77	0.21	0.52
Liver	1.35	0.40	1.23	1.23	0.95	0.38	1.49	0.97	0.31	0.59
Kidney	1.36	0.47	1.23	1.08	0.91	0.36	1.21	0.89	0.36	0.55
Brain	0.59	0.23	0.56	0.54	0.48	0.15	0.66	0.50	0.18	0.28
Lungs	0.97	0.30	0.88	0.63	0.57	0.17	1.02	0.58	0.23	0.38
Stomach	1.03	0.26	0.90	0.51	0.59	0.16	1.09	0.59	0.16	0.44
Milk										
Cow	0.12	0.06	0 22.	....	0.19	0.04	....	....	0.02	0.10
Human	0.04	0.01	0.05	....	0.05	0.02	....	....	0.02	0.02
Wheat										
White flour	0.36	0.16	0.17	0.47	0.41	0.09	0.61	0.30	0.29	0.37
Egg										
Raw, white + yolk	0.62	0.19	0.51	0.56	0.46	0.14	1.18	0.38	0.21	....

For all practical purposes the commonly used muscle and organ meats are of equal amino acid value with respect to these 10 amino acids and fish and chicken may adequately replace beef, pork, lamb and veal in the diet. The organs of beef contain smaller amounts of protein than are found in muscle and show greater differences in amino acid content,

but are good sources of protein as well as superior sources of vitamins and minerals. Meat is clearly one of the most satisfactory sources of dietary protein and its amino acid pattern might well serve as a guide in compounding successful protein mixtures from cereal and vegetable sources. This consideration is particularly pertinent when diets are seriously restricted by meat scarcity.

TABLE 7

Amino Acid Intakes of Infants, Boys and Man

Values in grams per day

	Infants	Boys	Adult Man
Protein nitrogen	1.30	13.0	14.2
Histidine	0.13	1.4	1.8
Arginine	0.42	4.3	4.7
Lysine	0.52	4.2	5.1
Tyrosine	0.51	3.5	3.8
Tryptophane	0.19	0.8	1.1
Cystine	0.21	0.9	1.2
Methionine	0.19	2.4	2.8
Phenylalanine	....	3.8	4.3
Threonine	....	2.9	3.4
Valine	....	2.8	4.2
Leucine	....	8.6	10.7
Isoleucine	....	2.8	3.3

With the determination of the amounts of some of the amino acids in the food nature provides for babies it was possible to estimate the amounts ingested by three infants for whom pediatric records showed excellent growth and health during periods in which their only food was their mothers' milk. Using the analytical values obtained in this laboratory and those available in the literature we were able to estimate the amino acid intake of four boys, ten to twelve years old, who were in excellent health and made satisfactory progress in growth by every criterion available while receiving the diet (37). In Table 7 the intakes of the infants and boys are shown with the recommended allowances of amino acids for adult man given by Block (85).

Recently, Block and Bolling (86) published a comprehensive volume on *The Amino Acid Composition of Proteins and Foods*.

The functions of the amino acids in the dietary are numerous. In the structural phase, the amino acids serve as building materials for tissue proteins. This requirement is great in the young animal. Amino acids also are required in both growing and adult animals to maintain the protein structure already present. Another function of the dietary amino acids is the support of metabolic processes involving the enzymes of the body, many of the hormones, the sympathin of the nerve fibers; hydrogen carriers such as glutathione; the bile acids; the antibodies which protect against invasion ot foreign organisms; and the creatine from muscle. All of these substances and probably many more are dependent ultimately on the available amino acid supply.

Following the close of World War I, Professor Mendel (12) summarized the knowledge of protein thus:

> Today we are concerned with the question whether this or that protein, whatever its biologic origin, will yield the characteristic desired amino-acids. . . . Our attention is fixed on the building-stones or units out of which the great protein structures are put together. Instead of referring to the proteins in terms of their physical properties or empirical composition . . . at least so far as the problems of nutrition are involved, the time has arrived for estimating their behavior in the organism on the basis of the quota of each . . . [of the] well-defined amino-acids. . . . In proportion as any specific protein can furnish these constructive units it may satisfy the nutritive needs of the body. The efficiency of the individual protein in this respect must depend on the minimum of any indispensable amino-acid that it will yield; for it is now known that some of them cannot be synthesized anew by the animal organism.

Protein in sufficient quantity and of the right quality is necessary for all forms of life: its relation to problems of health and disease are of great consequence. Dr. Frederick J. Stare of Harvard University listed (87) some of the physiologic problems of medical interest in relation to protein foods: growth, pregnancy, lactation, bone formation, blood formation, immunity and resistance, absorption of other nutriments, appetite, hunger and fatigue.

Vitamins

Vitamins and minerals are contained principally in the "protective foods," or "body-building foods," in contrast to the "energy foods." The word vitamin comes from the Latin word "vita" (life), plus "amine," since it was first thought that vitamins were amines. Although we have now an impressive list of known vitamins, there are probably others yet to be isolated and still more functions to be discovered for the ones we already know. The first vitamins were tentatively classified by Professor E. V. McCollum as "fat soluble" (dissolve in fat) and "water soluble" (dissolve in water) and the designation "A" given to the first and "B" to the second.

Such diseases as scurvy, beriberi, rickets and night-blindness have been known for centuries. Despite the fact that effective cures could be produced by the use of liver for night-blindness, and fresh vegetables and fruits (especially citrus) to cure and prevent scurvy, the diseases were not recognized as dietary deficiencies until after the beginning of the present century. The idea that disease was caused by a positive agent acting in the body (the earlier concept being that of a demon or devil and later identified as a microbe or bacterium) had become so firmly established that it was difficult to conceive of disease resulting from a lack or deficiency. Chemical analyses showed that body tissues consisted of protein, fat, carbohydrate, minerals and water. Since foods were of a similar composition or contributed like materials it was assumed that, if specific foods exerted any special benefit in certain diseases, which most physicians doubted, the results were attributable solely to the ability of the food to counteract an unknown toxic substance which was the direct cause of the particular disease.

However, certain investigators had not forgotten the pioneer studies of Magendie in the differentiation of the food value of the nitrogenous and non-nitrogenous constituents of the diet. In these experiments, conducted during the first part of the nineteenth century, Magendie initiated

the method which has come to be known as the ***biological response*** technique. In 1816, he published the results of his experiments with dogs fed on sugar or fat and water. The dogs died within three weeks when protein (meat) was omitted from the diet. In his report, Magendie tells of the condition of his animals and describes the ulceration of the cornea in the eyes of his dogs and the abundant secretion of the glands of the eyelids. Although Magendie did not recognize it as such, he presented a clear picture of xerophthalmia, or vitamin A deficiency.

Vitamin A animals only

In combination with protein, Vitamin A is an essential component of the visual purple in the retina of the eye. The vitamin is necessary to maintain the health of epithelial tissue and, in conjunction with other vitamins, vitamin A may exert a non-specific effect in preventing a lowered resistance to infections.

The condition known as night-blindness, decreased visual acuity in dim light, has been known since early times and the value of liver (a potent source of vitamin A) in its treatment was recognized in ancient medical practice. Study of the ancient Chinese Herbal has disclosed a long list of plant and animal foods, richer in vitamin A than cod liver oil, which were early used by the Chinese as remedies for night-blindness. At the beginning of the present century, epidemics of the eye disease resulting from vitamin A deficiency were observed in children of the Orient. For these cases a household remedy of chicken livers or eel fat was prescribed. The same disease, xerophthalmia, became so prevalent among Danish children, especially the poor, because of the exportation of butter, the use of skim milk in infant feeding and the substitution of vegetable fats for butter during World War I, that the Danish government was finally forced to remedy the situation by limiting the exportation of butter.

In several respects vitamin A is unique among the vita-

mins. It has one of the longest histories of causing untold human misery and suffering, was the first to be identified as an essential nutriment and the first among the vitamins to have its true chemical constitution established. But, most singular of all, so far it is the only vitamin not found in plants or synthesized by them. Apparently it is produced only by the metabolic processes of animals, from provitamins which can be synthesized only by plants (carotene and other carotenoid pigments commonly found in green and yellow plants). The most important and most abundant of these provitamins in the diet of animals and man is beta-carotene because, molecule for molecule, it is twice as potent as any of the other pigments. One molecule of beta-carotene breaks in two to give two molecules of vitamin A. The vitamin is a nearly colorless, complex, higher alcohol.

All animals do not have equal ability to convert the carotenes into vitamin A, but man apparently can do so normally with relative efficiency. Man obtains in his food both the vitamin itself and the precursor from animal tissues, but only the provitamins from plant materials. Both are absorbed through the intestine and transported by the blood to the liver for storage. The presence of bile facilitates the absorption of vitamin A and is essential for absorption of carotene, which appears to be less readily absorbed than vitamin A. The carotenes apparently are converted to vitamin A in the liver.

Regardless of the mother's diet the content of vitamin A in the liver at birth is lower than in adulthood. The liver reserve, or storage, increases gradually with age and in general the storage level in the liver is a reflection of the quantity of the vitamin in the diet. The ingestion of alcohol increases the blood level of vitamin A, apparently by mobilization of the supplies in the liver. The reserve supply may be lowered in infections and certain chronic conditions, particularly diseases of the liver. This may result from an increased metabolic demand for the vitamin, a decreased intake, or hindrance of the absorptive or storage mechanisms.

Vitamin D

Rickets, like night-blindness, appears to be a disease as old as the human race. It was described in infants and children as early as 1650, although filth and poverty were thought to be the cause. The disease results from a lack of calcium or phosphorus or of the vitamin D which is essential to their utilization in the formation of bony tissues. Rickets is confined to infants and young children. The counterpart of rickets in older children and adults is osteomalacia. Although cod liver oil had been used as early as 1824 as a therapeutic agent in rickets, the specific substance was not differentiated until 1922, when it was shown that the anti-rachitic agent in cod liver oil was an organic factor, different from vitamin A.

Vitamin D is not synthesized by plants or animals. Vitamin D bearing substances are produced when certain sterols—complex organic compounds of high molecular weight—are exposed to ultraviolet light. These sterols undergo a change in structure as the result of this exposure (irradiation) and the new compounds, which are known as *activated sterols*, are the true vitamin D substances. More than ten different organic compounds exhibit vitamin D activity but at present only two are of practical importance. In plants the provitamin is ergosterol and in animals it is 7-dehydro-cholesterol. Activation of ergosterol by ultra-violet radiation produces activated ergosterol, commonly known as *viosterol*. The pure, crystallized active substance in viosterol is known as *calciferol* or vitamin D_2.

Activation of 7-dehydro-cholesterol by irradiation produces vitamin D_3, which is commonly known as the animal vitamin D, since it is produced by the action of ultraviolet rays on the skin, hair and feathers of animals. Although fish oils contain other forms of vitamin D, the activated 7-dehydro-cholesterol appears to be the chief one. Likewise, vitamin D_3 represents the greater portion of the vitamin in eggs and irradiated milks.

Although vitamin D_2 and D_3 are closely related chemical

compounds, they are not only different in chemical structure but also in their biological action. In curing rickets in rats, one unit of viosterol or calciferol is equal to one unit of activated 7-dehydro-cholesterol. In the chicken, however, activated ergosterol is much less effective than the vitamin D_3. The human species appears to be more nearly like the rat in utilizing these different forms of vitamin D.

The activated forms of vitamin D appear to be readily absorbed from the intestinal tract in the presence of bile salts. The main storage depot in the body appears to be the liver, although the skin, bones and other tissues have significant quantities. One of the main functions of vitamin D is its role in the absorption of calcium and phosphorus from the intestinal tract. In vitamin D deficiency the absorption of calcium and phosphorus is decreased and larger amounts of these minerals are excreted. In rickets the phosphatase (an enzyme concerned in phosphorus metabolism) content of the blood serum is higher than normal and the giving of vitamin D causes a lowering of the serum phosphatase towards normal. Other functions of vitamin D have not been defined clearly but its action in bodily processes appears to be related to the functions of the parathyroid glands (glands which secrete a hormone controlling the level of blood calcium) and the thyroid gland (the gland which secretes thyroxin, controlling the rate of cellular metabolism).

Vitamin K

In 1929 hemorrhagic lesions in chickens fed purified diets were reported and in 1934 the conclusion was reached that this disease in chickens resulted from deficiency of a vitamin, then unknown, which was designated vitamin K. Later work showed that this vitamin was necessary for maintenance of the blood level of prothrombin, one of the factors essential for blood clot formation. In 1938 vitamin K was demonstrated to be essential in human nutrition through experimental treatment of hemorrhagic conditions resulting from deficient amounts of blood prothrombin.

Since that time pure vitamin K substances have been isolated, identified and synthesized and their effectiveness in man and animals clearly demonstrated. Vitamin K appears to function in the production of prothrombin, probably in the liver, and seems to be stored and utilized in that organ. For this vitamin to function properly there must be adequate absorption and the liver also must function, since large doses of vitamin K are ineffective in cases of severe liver damage.

Two natural forms of vitamin K have been identified: vitamin K_1, which occurs in the green leaves of plants, especially of such plants as alfalfa, spinach and cabbage: and vitamin K_2, which occurs in microorganisms, especially bacteria. The K vitamins are fat-soluble and have been found to be substituted derivatives of naphthoquinone. However, the situation with this vitamin is unique in that so many different compounds are known to exhibit vitamin K activity. In addition, related compounds have been synthesized which are not only water-soluble but are more potent in vitamin K activity than the naturally occurring vitamins.

Ascorbic Acid (Vitamin C)

Scurvy, the disease produced by a deficiency of vitamin C, has been known for many centuries. It was the most fearsome scourge of the early sea-farers and was called the "calamity of sailors." It attacked the populace of besieged cities, armies and prison inmates. It caused great suffering and loss of human life in times of famine. The observations, among the crews of sailing ships, by the Englishman James Lind, showed before 1750 that fresh fruits and vegetables in the diet not only prevented scurvy but cured it. Despite this classical evidence of a missing dietary factor in the production of scurvy it was nearly half a century before the British required the regular administration of lime juice to the crews of their navy. The true nature of scurvy as a dietary deficiency disease was not established, however,

until after 1900 when investigations of scurvy in Norwegian sailors showed a relationship with the scorbutic symptoms developed by guinea pigs on cereal diets. Addition of fresh vegetables to their diet cured the disease and led to the conclusion that scurvy was due to the absence of a specific chemical factor in the diet which was destroyed by cooking.

Vitamin C, or ascorbic acid, as it is now called, is closely related to the simple sugars in chemical structure. It is readily soluble in water and the basis for its determination depends upon its ability to decolorize an organic dye (strong reducing properties). In solution it is readily destroyed by air (oxygen), light, and by traces of metals such as iron and copper. Man, monkey and the guinea pig are the only animals known to develop deficiencies of vitamin C; all others apparently have the ability to synthesize it.

Ascorbic acid is readily absorbed from the intestine and distributed throughout the body fluid and tissues. It appears that little if any storage of the vitamin occurs in the body although certain organs such as the adrenal glands contain large amounts of it. The white corpuscles of the blood contain significant quantities of vitamin C and apparently reflect the general concentration of the vitamin throughout the body tissues. It is probably necessary for the formation of collagen, the intercellular cement substance which is an important constituent of connective tissue, capillaries, bones and teeth. Vitamin C may function in certain respiratory enzyme systems in the body and in the detoxification of certain bacterial poisons, but as yet no clear cut role can be assigned to the vitamin in these processes.

Thiamin (Vitamin B_1)

Beriberi, which results from a deficiency of thiamin, has been known for many centuries, particularly among the rice-eating inhabitants of the Far East. The great economic loss and human wastage caused by this disease led to its intensive investigation by the Japanese Navy and Dutch Colonials before the turn of the present century. The pioneer work in

the experimental dietary production and cure of polyneuritis in chicks was accomplished in the latter part of the last century. Concentrates of this water-soluble vitamin prepared from rice polishings resulted in the vitamin hypothesis in 1912. It was not until 1926, however, that the vitamin was isolated in crystalline form. Ten years later the structure of thiamin was determined and the vitamin synthesized by Dr. R. R. Williams.

Thiamin or vitamin B_1, is a complex organic compound but unlike the fat-soluble vitamins and vitamin C, which are composed only of carbon, hydrogen and oxygen, thiamin contains in addition, nitrogen, sulfur and chlorine. Thiamin hydrochloride in neutral or alkaline solutions is easily destroyed by heat. The vitamin is readily absorbed from the intestinal tract and is distributed in the tissues and cells of the body. Such tissues as the heart, skeletal muscle, kidney, brain and liver have relatively high contents of thiamin. The vitamin is stored in the body to a limited extent and the excretion in the urine reflects the intake and tissue concentration.

In the body, thiamin is phosphorylated to form a coenzyme, cocarboxylase (thiamin pyrophosphate ester), which is essential in the oxidation of sugar. If thiamin is absent, pyruvic acid, a normal intermediate product of carbohydrate metabolism, accumulates in the tissues, whereas in the presence of sufficient cocarboxylase to form the enzyme it would be rapidly destroyed. This essential role of thiamin in the oxidative processes of the body appears to be its primary function, and whether other possible functions of thiamin are specific or related to its role as a coenzyme are not established. Thiamin is known to be essential for normal growth and development, appetite, normal function of the intestine and cardiovascular system, and the maintenance of healthy nerve structures.

The essential role that thiamin plays in the body metabolism, particularly in the metabolism of carbohydrate or sugar, has led to a consideration of thiamin requirement in

terms of caloric intake. Dr. George R. Cowgill (88) has worked out a mathematical expression which relates the vitamin-calorie ratio in the diet to the body weight. If the prediction formula is correct then the minimum daily intake of thiamin for a man weighing 70 kg. (154 pounds) and eating 2500 calories per day would be 746 micrograms daily. The fundamental feature of this mathematical expression is the relationship between the vitamin B_1 requirement and the energy metabolism. The present recommended daily intake of thiamin in planning a good practical dietary is 0.6 mg. or 600 micrograms of thiamin per 1000 calories in the diet. This means then an average man of 70 kg. (154 pounds) weight who is ingesting 2500 calories of food energy daily should receive 1.5 mg. or 1500 micrograms of thiamin each day. The relationship of thiamin to calorie exchange in the body has numerous clinical implications. If the energy metabolism of the body is increased, the thiamin requirement is increased. In cases of hyperthyroidism or overactivity of the thyroid gland, prolonged fever, or treatment with a high calorie diet the thiamin intake should be increased. Likewise, this is true for such states as growth, exercise and pregnancy, where there is a normal physiological enhancement in metabolism.

Riboflavin (Vitamin B_2, G)

Riboflavin is also a member of the complex known as the B vitamins. Historically it was not recognized as a vitamin until the early part of the last decade (1933) although it had been isolated in impure form from milk whey as early as 1879. By 1917 workers in this field of research were realizing that the original water-soluble B vitamin contained more than the antineuritic vitamin (B_1 or thiamin). This first division of the B complex in the early twenties led to the designation of the heat labile, antineuritic part of the B complex as vitamin B_1 and the heat stabile, growth-promoting part as vitamin B_2, by foreign workers, and as vitamin G in America. In 1933 several groups of workers identified

vitamin G with a group of water-soluble, yellow-green fluorescent pigments widely distributed in plant and animal products. Further, it was indicated that the pigment was similar to that found in the "yellow enzyme" isolated from yeast the year previous. These pigments, known as flavins, were shown to promote the growth of animals receiving diets deficient in vitamin G, but at first it was thought that flavins from different sources were different in their growth-promoting activity. Depending on their source they were designated as ovo-, lacto, and hepato-flavins, derived from egg, milk or liver, respectively. Within two years (1935), however, the constitution of the pigment, riboflavin, was established, it was synthesized and was shown to be the growth-promoting substance common to the various natural source materials.

Riboflavin is an orange-yellow, water-soluble compound which shows a characteristic yellow-green fluorescence. It is relatively heat-stabile but is readily destroyed by light. The vitamin may occur in natural materials as the free vitamin (riboflavin), as an ester with phosphoric acid (riboflavin phosphate) and in combination with protein (flavoprotein). The latter is a specific enzyme which functions in cellular respiration and riboflavin is an essential constituent of such enzyme systems, for in animals which are riboflavin-deficient the tissues have a reduced content of the specified enzymes of which riboflavin is a component.

Riboflavin is distributed throughout the body, such tissues as liver, kidney and heart being especially rich in this vitamin. However, there appears to be little, if any, storage of this vitamin since on the average diet it is constantly being excreted in the urine. With a high intake the urinary level rises, decreasing as the content of the diet is lowered. The urinary excretion of riboflavin seems to indicate, as with thiamin, the level in the intake and the saturation of the tissues. Of all the numerous functions that have been ascribed to riboflavin, only its role as an essential component of various oxidative enzyme systems in cellular respiration

appears to be established. As such, it is believed that adequate supplies of riboflavin are necessary for the transportation of oxygen in the cells of the body.

Niacin (Nicotinic Acid)

A disease known as canine black tongue and resembling human pellagra was produced experimentally in dogs as early as 1917 by Chittenden and Underhill of Yale University. However, not until 1928 was it demonstrated that substances which cure the canine black tongue are also effective in the prevention and cure of pellagra in man. Demonstration, in 1935, that nicotinamide (the amide of nicotinic acid) was a component of a coenzyme was followed by the observation in 1937 that this compound was essential to the growth of single cell organisms. In this same year, workers at Wisconsin cured canine black tongue with nicotinic acid and the first successful treatments of human pellagrins with this compound were made by workers in Indiana and California. Widespread application of these results was furthered by many clinicians, notably Spies and Sebrell.

Unlike the other vitamins, identification and synthesis of the hitherto unknown vitamin was unnecessary. The compound, nicotinic acid, had been identified and its structure and synthesis worked out as early as 1870. This chemical compound has the unique distinction, thus far, of sitting on laboratory shelves for over fifty years without any indication of its value in efforts to maintain health. Nicotinic acid is an organic acid compound which is related chemically to nicotine, the alkaloid obtained from tobacco. In fact, the compound was originally discovered by the oxidation of nicotine. However, the physiological activities of the two compounds are unrelated. Nicotine is a poison whereas nicotinic acid is essential to the health of man. The vitamin occurs in practically all living cells in varying amounts, in the form of the amide of nicotinic acid or as a component of two important coenzyme systems. Free nicotinic acid occurs in the urine.

There were many objections to the term nicotinic acid because of the possibility of confusion with nicotine. Therefore, the vitamin and its amide form have been named niacin and niacin amide.

The importance of niacin resides in the fact that it is an essential component of two important cellular coenzymes which take in both glycolysis (sugar-splitting) and respiration: coenzyme I (diphosphopyridine nucleotide) and coenzyme II (triphosphopyridine nucleotide) differ only in their numbers of molecules of phosphoric acid. In a deficiency of this vitamin, the coenzyme I, or cozymase, contents of liver and muscle tissues are decreased. Man, dogs, monkeys and pigs require this vitamin in their diets; such animals as rats and chickens apparently have the ability to synthesize it.

Administration of therapeutic amounts of niacin (nicotinic acid) sometimes causes flushing and irritation sensations of the skin. These reactions do not occur when the amide form (niacinamide) is given. If the acid is given, the conversion to the amide appears to take place immediately after absorption. The amount of storage in the body does not appear large although such tissues as liver, kidney and muscles have a relatively high content of the vitamin.

Other Vitamins

There are other vitamins and vitamin-like substances which are essential to plant and animal life. At present, however, their "essential" nature in the diet of man is not determined and deficiency diseases related to these factors have not been recognized or described. Nevertheless, this does not mean that they are unnecessary or that the human body is capable of synthesizing them. Most are widespread in natural foods, particularly in those foods which supply the dietary factors known to be essential, and therefore probably are furnished in adequate quantities by a diet which provides the known essential vitamins. Lack of adequate amounts of the following substances in the diet produces

signs and symptoms of deficiency disease in experimental animals.

Vitamin E is sometimes called the fertility vitamin, or antisterility factor. Lack of this vitamin, which is fat-soluble and known chemically as *a*-tocopherol causes reproductive failure in rats and changes in the muscular and nervous systems of rabbits, guinea pigs and chickens, resulting in muscular dystrophy and paralysis.

Pyridoxine, or vitamin B_6, is essential in the diet of rats, dogs, chickens and pigs. Lack of it produces acrodynia (a form of dermatitis), a loss of hair and anemia.

Pantothenic acid is another member of the B complex which has been shown to be necessary in the diet of rats, chickens, dogs and possibly pigs. A deficiency of this vitamin produces necrosis (death of cells) in the adrenal glands of rats and causes graying of the hair in black or piebald rats, from which it has at times been called the anti-gray hair vitamin. In dogs, an acute deficiency produces sudden collapse characterized by changes in the chemistry of the blood. In chickens, lack of this vitamin causes specific pathological lesions in the spinal cord. Other members of the B complex are biotin, inositol, para-aminobenzoic acid and folic acid, which are known to be essential for the growth of certain microorganisms and produce deficiency symptoms in animals.

One other substance should be mentioned in conjunction with this group of vitamins, choline, which has long been known to be a constituent of the complex fatty components essential in the structure of living cells. It is a component of the phospholipids, the best known of which is lecithin, commonly found in egg yolk, brain, liver, and soybeans. Although it has been shown that rats can synthesize choline, a deficiency of this substance can be produced in rats as well as in chickens and turkeys. Poor growth, fatty livers and hemorrhagic kidney lesions characterize this deficiency in rats. In chickens and turkeys it is essential, together with the mineral element manganese, in the prevention of the

condition called *slipped tendon*. The high requirements for choline during growth and the fact that it occurs in practically all the tissues of the body make it an important dietary essential, despite the possibility that the body can synthesize it from other materials.

Minerals

In the adult man less than one of each twenty pounds of body weight represents the minerals which are required for a strong skeletal framework and are essential in many of the other processes which maintain life and health. During the early years of the development of the science of nutrition, dietary considerations were limited to the protein, fat, and carbohydrate components. Later, vitamins and minerals were recognized as necessary but the true importance of both of these groups of food constituents has been recognized only in the past few years. Through physiological and biochemical investigations the minerals are now known to participate in almost every metabolic process of the body.

Calcium, magnesium, sodium, potassium, phosphorus, chlorine and sulfur compose about three-fourths of the total mineral content of the adult body. In maintaining electroneutrality in the body the first four are positive, while phosphorus, chlorine and sulfur are negative. The distribution and amounts of these seven elements in the bodies of the fetus at six months, the newborn infant and the adult are given in Table 8 as calculated from values given by Dr. A. T. Shohl (89).

Calcium

Calcium is especially important in the growth and maintenance of bones and teeth. It is also needed in the process of blood clotting. About 99 per cent of the calcium in the body is involved in the construction and functioning of the skeletal structures. The amount of calcium required increases with size, rate of growth and other physiologic demands. During

pregnancy and lactation special attention must be given to providing a diet high in calcium. During the last half of gestation the calcium retained is used in repleting the maternal stores and in building additional maternal tissue, in meeting the demands of the fetus, and in preparing the maternal body for losses accompanying childbirth and post-delivery physiologic readjustments and the establishment of milk flow.

TABLE 8

Mineral Composition of the Body

	Fetus	Newborn	Adult
Body weight, kg	0.88	2.9	70
Total ash, gm	19	100	3,000
Per cent of total ash			
Calcium	28	24	39
Magnesium	0.9	0.7	0.7
Sodium	10	5	2
Potassium	7	5	5
Phosphorus	17	14	22
Chlorine	8	5	3
Sulfur	8	6	4
Total	79	60	76

Surveys of American diets demonstrate that they do not contain sufficient calcium for optimum health. It is known that a growing child whose height, weight and appearance are normal may have a calcium-poor body which even the best physical examination cannot reveal, but which may be revealed by X-ray examination. Lack of sufficient quantities of calcium may have serious consequence in the longevity and fruition of the race. Prof. Sherman and his students have shown that the calcium content of rat bodies at various ages is measurably influenced by the amount in the food eaten. To what extent such differences exist among human subjects remains to be determined. We know that an individual experiencing rapid skeletal growth, having augmented physiologic demands or possessing a subnormal concentration of calcium in the bony tissue may require larger amounts of calcium.

Phosphorus

Over 70 per cent of the phosphorus used by the body is devoted to formation and maintenance of the bones and teeth. Sufficient amounts of this mineral are exceedingly important in the diet of the growing child and the pregnant or lactating mother. Phosphorus is widely distributed in the body, combined in many forms in soft and bony tissues and associated with protein, carbohydrate, fat, various minerals and organic substances. Phosphorus is essential in the metabolism of fats and carbohydrates, and participates in many phases of metabolism and in the regulation of the proper alkalinity or acidity in the tissues, the secretions and the excretions of the body. It is generally assumed that if the calcium and protein needs of the body are met, the phosphorus requirement will also be covered, because the foods richest in the former are also the best sources of phosphorus. The phosphorus allowance should be at least equal to and probably somewhat greater than that of calcium.

Sodium, Potassium, Chlorine, Magnesium

Quantitatively, calcium and phosphorus are the most important minerals in the body but from the standpoint of function and the maintenance of health other mineral elements are equally essential. Sodium, potassium and chlorine (chloride) form a team in maintaining the proper balance of water and in controlling the electroneutrality of the body. Potassium is found inside the cells and sodium in the fluid surrounding the cells. Chlorine passes into and out of the red blood cells with shifts in the acid-base equilibrium (relative acidity).

During the ingestion of food and its subsequent digestion, copious amounts of chlorine-containing hydrochloric acid are secreted into the stomach. Perspiration contains appreciable quantities of sodium and potassium salts and during an eight hour day of strenuous labor in hot surroundings an individual may excrete 10 or more quarts of sweat, which will contain 3 or more grams of salt per quart or a total of

more than an ounce of salt. Such instances of extreme mineral losses from the body are not uncommon in heavy industry and during army maneuvers in hot climates. If the salt, as well as the fluid, is not replaced by additions to the diet, muscle cramps and prostration may occur. The usual practice in industry or in the army where conditions cause excessive sweating is to add salt to the drinking water or furnish salt tablets. These create a thirst for water and larger quantities of fluid are taken into the body to make up for excessive losses that have taken place.

Magnesium is found primarily in the skeletal framework of the body, associated with calcium, and in certain instances may replace the latter. About one-quarter of the magnesium content of the body occurs in the blood, other body fluids and the various organs and soft tissues. Magnesium has been found to be a component of cocarboxylase, the carbohydrate enzyme of which thiamin is an essential component.

Sulfur

Sulfur is one of the most important of the essential elements. It is a constituent of the amino acids cystine and methionine as well as other essential body substances such as insulin and thiamin. Inasmuch as sulfur is part of the amino acids methionine and cystine, it is primarily associated with proteins in the body. Most of the sulfur ingested comes from the dietary protein. There is a continual requirement for this element throughout life for the construction and repair of body tissues, although the needs of the body for sulfur in the form of the amino acids methionine and cystine may be largest during growth, pregnancy and lactation. Sulfur in the form of cystine is an important constituent of skin, nails and hair and as such is continually lost from the surface of the body and must be replaced.

Trace Elements

The classification of the various mineral elements necessary for the health of the body into the *principal mineral*

elements and the *trace elements* is based largely on their quantitative occurrence. The seven principal minerals occur in the tissues and fluids of the body in amounts which can be determined by ordinary chemical methods of analysis. The trace elements are found in the body in such minute amounts that special micro-chemical and electro-chemical methods of analysis are required for their determination. Such mineral elements as iron, copper and zinc might be placed in either classification, depending on the viewpoint of the nutritionist. However, since the choice is arbitrary the present consideration includes iron, copper, iodine, manganese, cobalt, and zinc among the *trace elements* essential to animal life. The trace elements are essential because they are structural components of such vital body constituents as hemoglobin, enzymes and hormones. Absence of these minerals from the diet may result in a deficiency disease and they are analogous to the vitamins, not only in their nutritional importance but also in the specific functions they perform in the physiological processes.

Iron is an essential constituent (0.4 per cent) of hemoglobin, the red coloring matter of the blood. A deficiency of iron, therefore, will prevent the formation of hemoglobin, and anemia results. This is particularly true in growing children and after hemorrhage, when new blood formation is occurring. The body needs for iron vary with age and other conditions. The demand during pregnancy is increased to supply the developing fetus. The newborn infant normally has a store, or reserve, of iron to carry him through the first months of life since milk, his basic food, provides only small amounts of this mineral. Women have a greater need for iron than men, under normal circumstances, in order to replace losses during menstruation. Besides its role as an essential constituent of hemoglobin, iron functions in certain enzymatic systems in the body.

Although copper is not a constituent of hemoglobin its presence appears to be essential for the formation of this iron-

containing protein pigment. In addition, copper functions in various enzyme reactions.

Iodine is one of the most important of the essential trace elements. Although it is widely distributed throughout nature, there are various areas in different parts of the world where the soil and water is notably deficient in iodine. Food grown in these areas lacks iodine and as a result animals and people living in such environments, unless their diets are supplemented, suffer from a deficiency. Iodine is a structural component of thyroxin, the hormone elaborated by the thyroid gland, which controls the rate of metabolism. In such conditions as puberty, pregnancy, lactation and infections, the thyroid gland requirement for iodine is greater and thus the dietary need of iodine is increased.

Other trace elements such as manganese, cobalt and zinc have been shown to be essential to animal life but have not had their functions in physiological processes clearly defined. Cobalt apparently functions in the formation of the red blood cells. Soil deficiency of this element in several different parts of the world produces anemia as well as other deficiency symptoms among populations of people as well as of other animals. An excess of cobalt produces polycythemia (supernormal red blood cell count). Manganese and zinc function as catalysts or activators in numerous enzyme systems essential to the metabolic and respiratory activities of the individual cells of the body. Zinc is apparently an important constituent of insulin, the hormone secreted by the pancreas, which is necessary for the oxidation of sugar in the body.

Other trace elements which as yet have not been demonstrated to be essential for life, but which may be important from the standpoint of optimal health and nutrition, are nickel, boron, fluorine, selenium and aluminum. There are indications that traces of nickel as well as cobalt may function in the synthesis of the hormone insulin. Boron is known to be essential to the life of plants. The element

fluorine is important for its effect on the teeth. In certain areas in this country excessive amounts of fluorine in the drinking water produce, during the period of tooth formation, a condition of dental fluorosis or mottled enamel. The teeth are lusterless and chalky in appearance, pigmented and pitted. The observations that the incidence of caries is less in those individuals suffering from dental fluorosis and that the enamel of sound teeth contains more fluorine than that of carious teeth, have led to the theory that small amounts of fluorine may be essential to the formation and maintenance of healthy teeth. Certain soils in the mid-western states contain relatively high concentrations of the element selenium. Vegetation grown on these soils contains large amounts of this element and promotes severe toxic symptoms in animals deriving their food from it. Although toxic symptoms in man have not been described, excretion of selenium by people in these areas is greater than that by those living elsewhere.

It is important to point out that although lack of an essential trace element may cause deficiency disease, an excess may be toxic, as with fluorine and selenium. In contrast, the element aluminum appears inert although it is found in very small amounts in plant and animal tissues. The widespread use of aluminum in baking powders (alum) and for cooking utensils has raised the question of its possible toxicity. However, only a small amount of aluminum taken in may be absorbed and no evidence of harmful results has been shown.

Chapter Seven

FOOD—AS EATEN

One of today's greatest challenges to the food manufacturer, the food technologist, the restaurateur and the housewife is the *conservation of food nutriments*. The processing of foods has become a necessity in food distribution and with it have come many critical nutritional problems. Because of the lability of some of the important food constituents there may be large losses of both organic and inorganic nutriments in varying degree depending upon the preservation methods used.

It was in the interest of "the improvement of public health by making possible a much broader investigation into the essential properties of materials which go to make up the food supply of the nation—the chemical, biological and physical properties of our food (90)," that a number of food industries combined to establish the Nutrition Foundation, Inc., in 1941. One million dollars was subscribed for the support, in 1942, of this pioneer organization through which the food industry acknowledged a definite social responsibility and function. Organization of the Nutrition Foundation set a pattern for American industry. Mr. George A. Sloan, President of the Foundation, reported (90) in 1943 that:

> The Nutrition Foundation is largely concerned with the basic fundamentals of nutrition. Many of these have early possibilities of practical application. Research in foods, or in any industry, is a combination of the fundamental and the applied. The Foundation is organized to investigate the new and the unknown, and to open avenues for development of more effective nutrition. It is also concerned with protection of food values now known, including new forms made necessary by war conditions.

The grocery stores of today sell "fresh" foods shipped to them from various sections of the United States, as well

as canned, frozen and dried edibles, but food as it is eaten is seldom comparable to the original product in nutritive value. Each step after harvesting or slaughter—storage, processing, cooking and serving—takes its toll of the nutritive qualities. These processes are necessary to prevent deterioration, to store food for future use, and to prepare food combinations which are convenient to use and appeal to the appetite. Losses of certain nutriments may be very great, depending upon the methods of handling. Analyses of foods cooked in the home and those prepared in industrial cafeterias show that enormous losses may occur unless precautions are observed which conserve the nutriments during the preparation. In America potatoes are a substantial source of vitamin C in the daily diet, yet the entire vitamin C content of potatoes can be lost in their preparation. Thiamin is also labile and may be destroyed during the cooking and serving of foods. Large amounts of minerals and vitamins are poured down the sink in cooking water. Other large losses result from too rapid cooking. Foods standing on steam tables or in warmers lose nutriments in varying degrees. Indeed, we are just beginning to learn what real food value means. In the words of Professor Mendel (15):

> We have seen that the problem of food supply is not one which can be dismissed by the social philosopher or solved by the calculations of the economist. It is highly complex with its involvement of factors and interests in agriculture, commerce, industry, and nutrition. Here, as in other domains, there is opportunity for an interplay of science and the arts, of experience and investigation. To attempt to foretell the future seems more like an act of ill-considered rashness than a keen intellectual venture. The truth can only be approached scientifically. We are beginning to learn what real food values mean.

Variation in Foods

Common plant foods vary a great deal in composition, particularly in their mineral and vitamin constituents. While the calcium, phosphorus and sulfur contents of some foods vary only 25 per cent or less, the amounts of the same elements in other foods vary as much as 200 per cent. There

are differences in individual composition, even among specimens of the same variety. With fruits and vegetables, these discrepancies are attributable to ripeness, species, type of soil, mode of cultivation, amount of water available, geographic origin and marketing conditions. Plant breeding has produced firmer, though whiter, heads of lettuce and cabbage and less green on celery but the green outer leaves are many times richer, not only in vitamins A and C but also in minerals. It is fortunate that green asparagus for canning has become more popular and the popularity of the bleached stalks has waned.

Our animal foods, also, are subject to variation in composition. The breed, age, feeding and activity of animals influence the composition of their tissues. Likewise, methods and length of storage and preparation greatly influence the nutritional value of meats and dairy products.

Bacteria

Many of our food manufacturing processes depend upon bacteria for their successful operation; other organisms cause decomposition and decay. The ripening process of the cheese industry depends upon bacterial action for successful conclusion. Food spoilage is caused by micro-organisms associated with air, soil and water, known as bacteria, molds and yeast. These organisms grow and reproduce very rapidly, during which they utilize the food to support their life cycles. In so doing they alter the odor, flavor or texture of the food. Enzymes or catalysts naturally present in all biological material may also cause food spoilage under certain conditions. Refrigeration greatly reduces food spoilage because bacteria do not reproduce rapidly in lowered temperatures. There are other factors that result in dissipation of nutriments. A bottle of milk which is allowed to stand on the doorstep in the sunlight will lose much of the nutritive value represented by its riboflavin content. Light and elevated temperatures are both destructive agents and reduce the nutritive value of foods.

Food Spoilage

Food spoilage is a larger problem than just preventing the deterioration which destroys value and attractiveness. Foods may seem unspoiled from their appearance, smell and taste, yet contain chemical substances or organisms which cause food poisoning and diseases such as undulant fever. This type of food spoilage at the source of supply and during processing has been brought under control, largely, by regulations enforced by the United States Government. However, after foods are purchased they must be kept properly to prevent contamination and wastage.

Losses in Storage

Wilting always causes a loss of vitamins C and A from foods, the amount of loss depending upon the temperature, humidity, length of time exposed, and the type of product. With fruits and vegetables the loss of these nutriments can be greatly reduced by carefully maintaining appropriate temperatures (91). For example, spinach at from 34 to 37°F. lost its vitamin C very slowly, whereas at room temperature it lost half in 3 days and nearly all in 7 days; on the other hand, peas lost little vitamin C in 6 days when stored at 34 to 48°F. but considerable at 64 to 72°F. Lima beans, shelled and unshelled, stored at 32°F. for eleven days lost 58 and 31 per cent, respectively, of their vitamin C content. Wax beans and Kentucky Wonder beans when stored for 6 days at 70 to 73°F. lost 81 and 58 per cent of their vitamin C content. Kale and New Zealand spinach lost half of their vitamin C content in 4 days at room temperature while the losses in broccoli and cauliflower were not so great. Potatoes may lose from 30 to 50 per cent of their ascorbic acid after a month to 6 months' storage and parsnips may lose 50 per cent of their vitamin C content after winter storage in the ground. These observations serve to illustrate how important it is to purchase fresh vegetables, and to store them in the refrigerator until they are used if the maximum nutritive value is to be derived.

Processing and the Preservation of Nutriments

Drying has been in use since the dawn of history, by widely different cultures and, with modifications to preserve some nutriments, is still used the world over. Brine (salt water) and smoking have been in use since earlier civilizations and are used to a limited degree today. Canning came into use with Napoleon's armies and was used in this country during the Civil War.

The processes of food preservation are principally those of (*a*) drying or dehydration; (*b*) freezing; (*c*) sterilization and canning; (*d*) chemical preservation, including pickling, smoking, spicing and fermentation. When every possible morsel of food was needed by the peoples of a war-torn world, dehydration, canning and quick-freezing became of greatest moment. Because of their keeping qualities and ease of handling, processed foods were the key to successful world-wide military operations. The processing and packaging of foods added new problems because the original nutritive value is invariably modified by the processing and further deterioration may take place during storage (Table 9), as was shown by Fitzgerald and Fellers (93).

TABLE 9

Ascorbic Acid Contents after Storage

Milligrams per 100 grams

	Broccoli	Spinach	Peas	Asparagus	Snap Beans
As purchased in wholesale market	77	35.0	15.5	12.5	10.0
Twenty-four hours later at 70°F	60	20.0	14.8	10.0	8.5
Forty-eight hours later at 70°F	50	18.5	14.0	10.0	7.5

Milk is "the most nearly perfect food." Furthermore, it is one of the most important individual products in our modern culture. The production and distribution of milk have attained high efficiency in the United States and it is available in many forms.

Various types of fluid milk are sold in the United States. The best known are certified, pasteurized, homogenized and skimmed milk, buttermilk and milk from certain breeds of cows, such as Holstein and Jersey. Fortified milk and milks which have been altered by special processing are also available. The Federal Food and Drugs Act sets no specific standard of composition and among the states the requirements vary considerably.

"Evaporated milk" (or unsweetened condensed milk) is whole sweet milk which has been concentrated by evaporation under vacuum to remove approximately 60 per cent of the water and processed in sterile cans. "Condensed milk" is sweetened evaporated milk, is 30 per cent water, 30 per cent milk solids and 40 per cent cane sugar. This type of milk is not used widely because of its sugar content. "Dried" or "powdered" milk may be either whole or skimmed milk which has had most of the water removed and may be prepared by different processes. Dried milk has the advantage of small bulk and being free of bacterial contamination. For all practical purposes, all forms of milk are nutritious and may serve to supply important nutriments in the diet.

Defatted milk solids and skimmed milk have been discarded in enormous quantities through the years. These valuable foods are highly nutritious and have served as excellent animal feeds. Yeast, a byproduct of the fermentation industry, has also found its way into animal feeds and fertilizer. Because of the vitamin, mineral and protein contents, both defatted milk and yeast are valuable foods that can be used to supplement and enrich the diet.

Yeast, which can be grown at low cost, is being considered as a source of protein, as well as vitamins. Dried food yeast is about 50 per cent protein and is rich in vitamins and minerals. It provides high quality protein in amounts double that in dried whole milk and in cheese and more than double that in meat, eggs and legumes. Yeast can be used in sauces, stews, soups, and in bread, in amounts up to 5 per cent, without affecting baking qualities or flavor. As a

constituent of bread, yeast protein very efficiently supplements the amino acid value of high cereal diets, for food yeast is relatively rich in lysine, in which gluten is deficient.

There are many excellent sources of protein which in the past have been discarded as human food. Some of these have been used successfully in supplementing animal feeds, some are used as fertilizers while others are thrown away as waste. Some of these rejected sources of protein are now being re-evaluated as human foods and many have already been diverted into channels for human consumption. It has long been the custom to remove the germ of the cereal grains in the preparation of flour and meals because its high fat content tends to cause rapid spoilage. The germ is not only rich in fat and vitamins but it contains an excellent grade of protein with a high biological value and digestibility. Likewise, a large portion of the bran and outer layers of the cereal grains is usually fed to animals. The latter are very rich in minerals and vitamins. The newer processes of milling have demonstrated that much of the nutriments that have been formerly discarded with the bran can now be retained in the flour, thus greatly enhancing its nutritive value. Dr. H. H. Mitchell has recently compared the protein quality of defatted corn germ with that of dried, defatted beef roundsteak. His studies indicate that the two types of protein are comparable in biological value. Wheat and corn germ might well serve as an effective supplement to the protein intake of the civilian population.

Soybeans long have been used in the Orient as one of their staple foods. The Germans have made use of them in their war-time diets. We have used soybean oil in salad and cooking oils and in margarine, but the bulk of the residue, which is exceptionally rich in protein of high nutritive value, has been used for livestock feeding and industrial purposes. Soybeans yield per acre a greater quantity of protein than any other vegetable plant and the protein is of nutritionally superior quality. Dr. C. M. McCay of Cornell University has promoted the use of sprouted soybeans and

present educational propaganda is to stimulate an interest in soybean products. The American people are beginning to use fresh green soybeans, dry soybeans and soya flour more generally.

Soybeans, peanuts and cottonseed have been used as sources of vegetable fat and the press-cakes (residue after extraction of the oil) carry proteins of high nutritive value, excellent mineral mixtures and some vitamins. Dr. Arthur H. Smith and associates of Wayne University College of Medicine (93) have recently tested on man the digestibility of the protein of soybeans, soybean flour and soybean milk and found them to be 90 per cent, 94 per cent and 90 per cent respectively. The biological values in the same order are 94 per cent, 92 per cent and 95 per cent. These values are in line with the best sources of protein, such as egg white which yields a biological value of 100 per cent.

Dehydration

Some dehydrated vegetables, soup mixtures, apples and peaches were used to supply troops during the Civil War. Between 1917 and 1919 nearly nine million pounds of dried potatoes, onions, carrots, turnips and soup mixtures were shipped to the American Expeditionary Forces. Many of these products were unsatisfactory from a culinary standpoint, consequently, the production of dried foods decreased following the war. In addition, the development of rapid transportation facilities by train and truck, mobile refrigeration, and diversified truck gardening made it possible to distribute fresh foods the country over during all seasons of the year.

In World War II, with soldiers in campaigns in so many theaters of war the world over, the Army was quick to realize the importance and advantage of the dehydrated, compressed and concentrated types of food. Shortage of transportation and scarcity of critical packaging materials focussed research on the fields of condensed and concentrated foods and on fiber packages. Dehydrated foods save millions

of cubic feet of shipping space. In addition, there is less waste and less-valuable materials are used in packaging and storing. One freight boat can carry as much food in dehydrated form as eight or more boats loaded with the fresh products. With government help the food industry succeeded in developing processed food products that met the stringent requirements of modern warfare and meet those of the civilian population as well. The basic developments sought by this food-research program were high nutritive value, palatability, stability and suitability both in variety and packaging. Dried vegetables, fruits, eggs, milk and meat were shipped overseas. Successful efforts in maintaining the vitamin contents of dehydrated foods are shown by the values reproduced (94) in Table 10.

TABLE 10

Vitamin Content of Dehydrated Foods

Milligrams per 100 grams

	Thiamin	Riboflavin	Niacin	Ascorbic Acid	Carotene
Potatoes (white)	.02–.16	.05–.10	4.5–6.4	11–25	0–.10
Potatoes (sweet)	.05–.20	.13–.15	1.5–2.1	14–23	11–16
Cabbage	.30–.50	.18–.45	2.4–4.3	135–268	.05–.5
Carrots	.27–.35	.18–.35	2.5–4.0	10–16	69–108
Tomato juice cocktail	.30; .34	.27; .30	7.5; 8.8	90; 135	4.9
Beets	.15–.20	.25–.32	1.31–1.7	0–2	.02–.05
Onions	.35	.12; .3	1.1; 1.3	21; 35	.05
Cranberries	.2	.03; .15	.5; .9	2; 28	.75
Apple nuggets	.07	.05	.6	11	
Navy bean soup	.3–.4	.15–.40	1.6–4.5	.05–2.8	.03–.04
Yellow pea soup	.4	.15; .35	2.1; 4.5	.2; 5.5	.12
Green pea soup	.4–.44	.13–.30	2.9–4.7	.3–4.1	.11–.12

To produce palatable and attractive servings with the dehydrated foods requires considerable experience. The Quartermaster Corps (Q.M.C.) found in its initial experiences with dehydrated foods that to get the best results cooks needed special instructions to make best use of these products. With the cooperation of the industrial laboratories and the Subsistence Research Laboratory, a cooking and serving manual was prepared and a special course of instruction was set up for key personnel from the cooks' and bakers' schools.

These, in turn, gave instructions which would assure the dehydrated foods being served in an acceptable manner.

Desirable as dehydrated foods are from the transportation point of view, many difficulties have arisen in the preparation of them. For the majority of fruits and vegetables sun drying does not produce as satisfactory a product as a dehydration process where temperature, humidity and time of exposure can be controlled. One of the first requisites to preservation is that the food be fresh and handled carefully to avoid bruising and injury before preparing for drying. Any breakage of the cell walls permits the escape of enzymes, which causes darkening, impairment of flavor and dissipation of vitamin content when exposed to air.

To preserve the vitamin C content and prevent darkening during the dehydration process, sulfuring is used. Apples, for example, are cut and the pieces held in one per cent salt solution (brine) to prevent darkening. The cut fruit are sulfured either in a sulfuring house where they are exposed to the sulfur dioxide fumes of burning sulfur or they may be immersed in a dilute solution of sulfite (1 to 3 per cent sulfurous acid). The length of exposure varies with the kind of fruit and the size and shape of the pieces. However, the final color of the product will depend upon the exposure to light, the drying heat and the humidity during the dehydration process.

In general, fruits lend themselves better to sundrying than do vegetables and some varieties of fruit are more suitable for drying than others. Vegetables are not so successfully dried in the sun although on farms corn is frequently sun dried for winter use. The earlier settlers dried beef and meats of many kinds. Salted fish is dried in considerable quantities in certain parts of the country.

There are various types of dehydrators, all of which aim at removal of the excess water without destruction of cellular tissues or impairment of the food value through overheating. The drum dryer may be atmospheric or vacuum, consisting of steam-heated drums 2 to 6 feet in diameter to which the material to be dried is applied. The drums revolve and

the materials dry and are scraped off before a single revolution is made. The methods vary for feeding the material on to the drum and in handling it after it is dried. Milk, certain vegetable juices, cranberries, bananas and certain kinds of meat are dehydrated by this method. In the vacuum drum dryers, the drum is enclosed in a housing which will withstand high pressure and heated by steam coils to the desired temperature. Any products which may be injured by drying in contact with air are prepared in the vacuum drum dryers.

Materials in solution may be dehydrated by spray dryers in which a solution (or suspension) is forced, in a fine spray, through heated air which transmits its heat to the individual droplets, evaporating the moisture, leaving the solid behind in powder form to settle through the stream of air. This method has been successfully applied to whole eggs, egg yolks, blood serum, milk, and certain fruit juices.

Blanching

To inactivate the enzymes and to prepare the food product, vegetables may be blanched before canning or freezing, that is, they are immersed in boiling water for one or more minutes, depending upon the food. Blanching not only inactivates the enzymes but it expels air, which avoids straining the hermetic seal used in processing and reduces the volume, enabling compact packing of containers. Raw vegetables respire but the gases are low in oxygen content since the respiratory process constantly takes place and uses up the oxygen within the tissues. After the vegetables are blanched and their oxygen-consuming enzymes are inactivated they may become saturated with oxygen. Under such conditions, if a low temperature is not at all times maintained there will be a great loss of vitamin C, as has been shown by Todhunter and Sparling (95).

Frozen Foods

Freezing was one of the early methods of preservation but with fresh and canned foods on the market, people were indifferent at first to the new "quickfrozen" foods. Gradually,

however, interest grew and this method of preservation gained favor and was encouraged to expand. In 1942, although there were many unsolved scientific problems having to do with the process itself and with packaging, shipment and storage, the product offered many advantages, especially to the armed forces in isolated sections where perishable foods are not available. There is no waste, therefore less shipping space is required. No preparation is necessary prior to cooking and the actual time of cooking is much less than for the fresh product. The taste in most cases simulates closely the fresh food. The food industries and private laboratories pooled efforts with the government in solving many of the problems occasioned by the great expansion of the number of frozen foods and the tremendous volume ordered by the armed forces.

Not all vegetables are satisfactory after freezing. The flavor of some may become quite undesirable. Research has demonstrated that enzyme activity is responsible for some of the difficulties encountered. Freezing does not completely inhibit this activity. As with canned foods, it has been found that blanching to destroy the enzymes is essential in preparing vegetables for the quick freezing process. In addition, the so-called quick freezing of vegetables reduces the development of microorganisms as well as the action of oxygen on the food. After the enzyme action is inhibited by blanching the vegetable becomes saturated with air and if the foods are not held at a low temperature the oxygen becomes a serious agent in destroying the vitamin C content of the food. For this reason frozen fruits should not be thawed until time for their use. Cooking the vegetables directly from the frozen state reduces the possibility of exaggerated losses of vitamin C during slow thawing and exposure to the air.

Canning

Food preservation by the application of heat to food in a sealed container is among the more modern methods. It

was devised about 150 years ago by a Frenchman, Nicholas Appert. His early text describes canning procedures for more than 50 foods. In 1811 Appert published his classic book *The Art of Preserving All Kinds of Animal and Vegetable Substances for Several Years.* Although Appert recognized the importance of cleanliness and careful sealing, it remained for the Frenchman Louis Pasteur to disclose a half century later that minute living organisms caused food spoilage and that they could be destroyed by heat. At the turn of the 19th century, vessels of glass, pottery and tin were used as containers for canned products. In 1819 the first canning factory was started in Boston and a year later was duplicated in New York.

It was not until the Civil War that canned foods were used for troops in this country. They were widely used in the Spanish-American War and World War I. More than 300 different canned foods are now produced and the factory value of milk, fruits, vegetables and soups alone total more than a billion dollars per year. The canning industry has grown because research has continuously demonstrated better ways of preserving the nutriments and increasing palatability and appearance of the canned product. The ability to can foods in the home and in factories has permitted better distribution of foods throughout the year; it has permitted preservation and storage of food in times of plenty for times of scarcity.

The chief principle involved in canning food is the application of sufficient heat to destroy the bacteria, yeasts and molds that spoil foods. Canning does reduce the nutritive value of food, though this loss is small if modern methods are followed. Also, there is continued loss of certain nutriments during storage, but despite these losses during both canning and storage, these products may even be superior to so-called fresh products that are purchased in the open market. For commercial canning, foods are selected at the peak of their nutritive value and are brought immedi-

ately from the field to factory with only a few hours between the time the food is gathered until it is canned.

The ordinary processes of canning usually do not affect the vitamin A content, but the thiamin content is reduced. There may be around 20 per cent thiamin loss in evaporated milk and an additional loss of 30 to 40 per cent with eight months storage. The loss of vitamin C depends upon whether there is an acid medium and whether contact with air has been in large measure avoided during the canning process.

Cooking

The different methods of cooking have varying effects upon the vitamin, mineral and protein contents of food. Drs. Bernard L. Oser and Daniel Melnick (96) of the Food Research Laboratories in New York City have made an assessment of the vitamin and mineral values of foods, as eaten, in a study of the influence of cooking procedure upon retention of these nutriments in vegetables. These investigators used (*a*) a "new improved" method with minimum quantities of water in a tightly covered pan, steaming until the vegetables were cooked, and (*b*) an "old-fashioned" method in which large quantities of water were used, and the vegetables brought to a boil in a loosely covered pan and simmered until cooked, permitting free escape of steam (Table 11). The authors conclude that the "new-improved" cooking procedure results in greater retention of nutriments. In summarizing, they say:

> The large losses of vitamins noted following the old-fashioned method of cooking, averaging 31 per cent, were greatly reduced by the new-improved procedure so that on the average more than 90 per cent of these nutrients were retained. The losses of minerals in either case were not large, averaging 12 and five per cent, respectively.

Workers at the New York State Experiment Station (97) observed a loss of 10 to 30 per cent of ascorbic acid in cooking cabbage. The cooking water may extract as much as 66 per cent of this nutriment. Carrots lost 14 per cent of their

vitamin C, whether boiled or steamed but the steamed carrots contained all of the vitamin C remaining whereas the water in which carrots were boiled contained vitamin C in proportion to the amount of water used. Unless the water were used in food the intake from the steamed vegetable would be much higher. It is evident from the citations above that the nutritive value of a food as it is eaten not only depends upon the original nutritive content but upon the methods of cooking and serving.

TABLE 11

LOSS OF NUTRIMENTS IN COOKING BY OLD AND NEW METHODS (96)

	Peas		Carrots		Potatoes		Broccoli	
	Old	New	Old	New	Old	New	Old	New
	Percentage loss							
Carotene	18	10	6	4	..	..	0	0
Thiamin	46	6	..	..	30	4	44	5
Ascorbic Acid	32	14	..	..	12	2	53	33
Riboflavin	31	7	..	..	45	3	37	27
Niacin	36	3	29	1	26	0	64	12
Calcium	5	0	7	1	11	13	29	19
Phosphorus	9	4	7	0	24	0	27	14
Iron	0	1	14	3	17	8	0	3

The losses of thiamin and ascorbic acid in quantity cookery may be as great as 95 per cent according to Nagel and Harris (98), of Massachusetts Institute of Technology. In general these results have been verified and extended to include other vitamins by Heller, McCay and Lyon (99) of the School of Nutrition, Cornell University. Studies conducted at one of the cafeterias feeding 1400 office workers and 1000 to 1400 industrial workers at the Brooklyn Navy Yard were designed to give an approximation of the losses of vitamins in large-scale cookery. Samples were collected (*a*) raw, or frozen (before defrosting); (*b*) immediately after

cooking; (*c*) of the cooking water immediately after vegetables were cooked; and (*d*) of the food in the steam table when the serving ended. The losses, in per cent, ranged as follows: thiamin 16 to 64; niacin 2 to 61; riboflavin 22 to 45; ascorbic acid 27 to 90. Such losses demonstrate the need for more careful control of cooking and serving procedures in order that food eaten may have a larger quota of nutriments. Unnecessary dissipation of nutriment may be avoided by (*a*) using fresh foods as soon as possible after delivery, keeping fruits and vegetables fresh and crisp before serving raw or cooked; (*b*) cooking such food products with little added water and minimum exposure to light and air so that vitamin and mineral losses are not accentuated; (*c*) serving promptly without long periods of standing on steam tables or in warmers; (*d*) using short cooking methods, i.e., broiling when possible for meats or roasting at low temperature.

TABLE 12

Percentage Thiamin Loss in Toasted Bread (91)

Seconds	White Unenriched	White Enriched	Whole Wheat
30	9.2	5.2	4.0
50	19.7	13.0	12.5
70	31.4	17.0	21.0

Apples in apple pie may lose 80 per cent of their ascorbic acid during baking, and an additional 8 per cent during a subsequent 48 hour period. In baking bread as much as 5 to 9 per cent of the thiamin may be dissipated; in home baking loss of as much as 30 per cent of this vitamin has been observed. Breads raised with yeast do not lose as much as "quick" breads. Losses in toasting may be greater than those which occur in baking (Table 12) and are in proportion to the toasting time. Eight out of ten people are said to prefer the 50 second toast. Forty per cent of the thiamin in bread is lost in making melba toast. When bread is relied upon to furnish a considerable portion of the thiamin intake, the recommended allowances can hardly be met if the bread is toasted.

Saving leftover food and reheating, a usual kitchen practice, results in further losses of nutriments. Mashed potatoes when stored in a refrigerator for two days may lose 40 per cent of their ascorbic acid content when kept in a covered dish but 50 per cent when held uncovered.

Pureed Foods for Infant Feeding

To ease the burden of the harassed mother, to insure babies of the best food with the highest potential nutritive and hygienic qualities that food processors are able to produce, baby foods have found and held a place of high importance in modern infant feeding. They range in variety and numbers from soups, cereals, meats, vegetables, fruits, to tasty desserts. For the infant three months old strained vegetables and fruits are available. Animal protein can be introduced to the diet gradually in strained meat-and-vegetable combinations and after the child has teeth the larger cans of chopped food can be used. In addition to their attributes of constancy, sterility and ease of preparation, baby foods permit cultivation of the child's appetite for a wide variety of foods and aid in establishing good food habits.

Fortification

Nutritional requirements can and should be met from a wide selection of natural foods. Meals should include a wide selection of vegetables, fruits and meats, as well as sufficient milk. Millions of families, though, eat only a few foodstuffs because they do not have enough money to buy the "fancier" foods, or live in areas where they are not accessible. Also, a great many of our foods are no longer "natural." While the original product may have had high nutritive value, modern methods of processing sometimes remove major portions of the nutritive elements.

Taken as a whole, the American diet is a marginal one. We do not find widespread such deficiency diseases as beriberi, pellagra and scurvy, although they do occur in some of the poorer communities. We have no statistics on the prev-

alence of "subclinical" deficiencies—deficiencies which are not severe enough to cause visible physical symptoms, but may only be reflected in irritability, tiredness, or an uncooperative attitude. Studies show that two-thirds of most "good" American diets are made up from "energy" foods and the remaining one-third—"protective foods"—must take care of the day's vitamin and mineral requirements. As a result, for unusual demands placed upon the body by growth, pregnancy, lactation, disease or nervous strain, the body is not receiving enough protective foods to meet its needs.

If our modern methods of food preservation and preparation have resulted in a loss of vitamins and minerals, the logical plan would be to devise and apply technological methods which prevent these losses. Unfortunately, there are many practical considerations which hamper attaining this objective. We have been aware, since childhood, of the campaign to influence people to eat whole wheat bread instead of white, but the number of converts is relatively small. It isn't feasible or desirable to stand over everyone at mealtime to be certain that he consumes the foods he should, and so the procedure of fortifying common foods was instituted. Dr. Lydia J. Roberts (100) aptly stated:

> The line of least resistance, therefore, might be to add to certain basic foods which are consumed in largest amounts by the mass of the people the dietary essentials that have been shown to be most lacking in the usual diet, so that no matter what they eat, they would "willy-nilly" have an automatic source of the dietary essentials.

Fortification, then, is only a first aid measure. It is an emergency method of attempting to assure an adequate intake of the essential nutritional elements when it is impossible to or impractical to insure their consumption in natural foods. To serve its purpose, it must not increase the cost of the fortified product. A ragged mountaineer will come into the general store and ask for white flour which makes up a large part of his meal—if it's fortified with vitamins and minerals he isn't concerned, if it will make bread and biscuit equal to those to which he is accustomed. If

the price of the flour, though, has been raised because of the fortification, he cannot buy as much of it, and the program has been to little avail.

Good nutrition demands that wherever possible requirements be met by natural foods. No food can or should (101) carry the full requirement of any nutriment:

> . . . the Council on Foods and Nutrition of the American Medical Association does not approve of the addition to foods of substances not found in the native article or in amounts in excess of the amount carried by the best foods of its class. The attempt to convert a food into a pharmaceutical product is frowned on, but the restoration of substances lost in preparing the food for the market is a recognized part of the nutrition program.

Salt

Our first fortified food has a history which goes back to fifteen centuries before Christ. The Chinese then were using substances to prevent goiter, although they did not, of course, know that these substances contained iodine. Sponge ash was widely used during the time of Hippocrates (400 B.C.) In our own country, residents of the White Mountains, in New Hampshire, at the end of the seventeenth century recognized the need for sea foods which contain iodine, and walked miles over the mountains to secure it. In more recent times, it has been found that native tribes, who have never heard of the words "iodine" and "goiter," are aware of the importance of sea food. The Indians of Peru used dried kelp so that they would not get "big necks" like the whites.

It was not until 1811 that iodine was actually discovered, and a few years later before it was knowingly used in the prevention of goiter. The first fortification of food took place in 1855, in Europe, where it was recommended that potassium iodide be added to table salt, or that sea salt be used with meals. This was attempted for a time, but opposition arose and it was not long before the practice died out. Interest in the subject was revived by Drs. Marine and

Lenhart of this country, who at the beginning of this century first showed the effect of low iodine intake in an experiment with brook trout. An interesting experiment was conducted a little later by Dr. G. E. Smith (102) who found that there were areas in the United States where pigs, born to apparently normal sows, were hairless, had little vitality and were poorly developed. Owners were losing as high as ninety-five per cent of every liter in these areas. Various investigations were conducted and, when all other causes were ruled out, a number of pregnant sows in an affected area were divided into groups, part receiving the accustomed food and the others receiving additional amounts of either sheep thyroid or potassium iodide. The sows receiving the regular diet produced pigs that were very poor, weak and dull, while those receiving the added thyroid or potassium iodide produced strong, healthy young.

About the time of World War I, Drs. Marine and Kimball in studies of school children in Akron, Ohio, showed that endemic goiter could be prevented in man as easily as in animals by keeping the thyroid saturated with iodine. With the revival of interest Switzerland, where goiter was very prevalent, reintroduced iodized salt in 1919 in some districts. Through the efforts of the medical association of the State of Michigan iodized salt was first introduced in this country in 1924. The campaign to use iodized salt was conducted through schools, parents, and magazines. Because of the prophecy of some that this dosage of iodine would prove harmful, salt companies were permitted to manufacture both iodized and uniodized products.

Iodized salt has been on the market over twenty years, and approximately fifty per cent of all table salt sold is iodized. Few measures have been so successful in improving the public health as this initial project in food fortification. In 1937 Dr. Roy D. McClure (103) made a survey of the incidence of goiter and the number of goiter operations since the introduction of iodized salt in Michigan (1924). During 1926 and 1927 the number of operations for goiter had

increased markedly. The increase in simple goiters during 1926–1927 was attributed to the reaction of iodine on a certain number of dormant thyroid adenomas (a type of goiter), which had brought these cases to operation sooner than might have been expected. There was no increase in other types of goiter during that period. However, records for 1928 showed the number of operations and the number of goiters in school children greatly decreased, a trend which continued until 1940 but was followed by a slight increase, perhaps because publicity on iodized salt was reduced.

Many shoppers believe that all salt is now iodized and too many people simply buy "salt." It has been suggested that to stimulate sales the iodized salt package display a statement of its value in preventing goiter and that the public be continually reminded that iodized salt has special virtue. Iodized salt discolors some foods in canning, and for that reason, although the food is not injured, salt that has not been iodized is usually used.

Pregnant women might well take a lesson from primitive tribes and the women of centuries ago who went to all manner of trouble to obtain sea food to include in their diets. Today women need not tramp over mountains and miles of territory to obtain a source of iodine—they need walk no further than the kitchen cupboard. And it is just as important today that the pregnant woman include enough iodine in her diet, not only to meet the needs of her own body, but also those of her unborn child. Insufficient iodine in the mother's prenatal diet results in "cretinism" in the child. A cretin is stunted, both physically and mentally, owing to the thyroid deficiency and the true cretin requires institutional care for his entire lifetime, yet few requirements in the prenatal diet may be met as effortlessly as the iodine requirement.

Milk

Milk was fortified as the result of exhaustive research on the best methods of adding vitamin D to the diets of children and adults. Natural vitamin D can be derived from foods

in appreciable amounts only from fish, liver and other viscera, eggs and milk, and the amounts ingested may not be sufficient for good health. Vitamin D is produced by the action of ultraviolet light upon the provitamin substances occurring in plant and animal tissues. Unfortunately, many factors make it impossible for many people to get sufficient sunshine the year around, particularly in large cities where residents have little opportunity to spend much time in the sun, and various factors such as soot, smoke and shadows from buildings reduce the amount of sunshine available. Night workers have reduced opportunities for exposure to sunlight and in-school feeding programs shorten the outdoor periods for children. A city where the sun is almost directly over head will receive much more benefit from sunshine in one hour than hours of sunshine in a city where the sun is low on the horizon, simply because the rays have less distance to travel when the sun is overhead, and less of the ultraviolet is filtered out. In some areas fogs allow people very little sunshine. Sunshine varies with the time of year; during the winter months we receive much less sunshine than during the summer. Alfred Hess has said: "In general, a map of the incidence of rickets is the practical equivalent of a map of deficiency in sunlight."

Dr. Alfred Hess and Dr. Harry Steenbock, in 1924, simultaneously reported the possibility of producing vitamin D in foods by exposing them to ultraviolet light, the process known as irradiation. Work was begun on irradiating milk and on feeding irradiated food to cows. Irradiated dry milk was the first product to appear on the market, in 1927. "Metabolized milk" from cows fed irradiated yeast, was available in 1932. The first fluid "irradiated milk" and "fortified milk" (milk to which cod liver oil concentrate has been added) were on sale the same year. An acceptable number of Vitamin D units per quart was established: irradiated, 135; fortified, 400; and metabolized, 430. Since that time producers have been able to raise the number of units in each quart of irradiated milk to about 400. Recently,

too, irradiated ergosterol (viosterol) has been used instead of cod liver oil for fortifying milk. Thus, all three types of vitamin D milk are produced by irradiation—one by irradiating the milk itself; one by irradiating food fed the cow; and the third by adding an irradiated substance to the milk. There are various factors which determine which type of vitamin D milk your dairy offers for sale—the comparative cost of feeding cows the irradiated yeast, of adding commercial vitamin D, and the cost and availability of apparatus and labor to irradiate milk.

The irradiation process was patented by Dr. Steenbock, who wished to give the public the benefit of his discovery and protect them against careless irradiation. Soon after he had patented the process, it became so valuable that the details of administration left him little time for his scientific work. Dr. Steenbock then tried to turn the patent over to some university, but the responsibility was so great that none of them wanted to take it. A group of alumni of the University of Wisconsin agreed finally to incorporate as the Wisconsin Alumni Research Foundation and take over the patent. Dr. Steenbock surrendered the patent with the stipulation that the money derived therefrom should be used for research work in the interest of human welfare.

Vitamin D milk was never intended to be a medicine; it was developed to help children and adults obtain their everyday requirement of vitamin D in regions where natural sources are inadequate or unused. This fortified food has proved so successful in preventing rickets and osteomalacia that the Food and Nutrition Board of the National Research Council has recommended that all milk sent abroad for relief purposes should be vitamin D milk.

Margarine

To a great many people, margarine is associated with war. They became very familiar with it during World War I, and renewed their acquaintance in World War II. Perhaps not all of them realize, however, that most of the margarine

offered for sale today is a changed product—most of the brands now belong to the group of fortified foods.

During the first war, fat content was the only consideration in the use of margarine. Since then, studies of its nutritive value have been made with the thought of making it a better substitute for butter. Butter's chief nutritive value, aside from providing fat, is its vitamin A content, therefore, this vitamin is now added to most margarines. The amount present in butter varies with season and breed of cows, but the average is 9,000 United States Pharmacopeia (U.S.P.) units per pound. In 1941 the Food and Drug Administration (104) adopted a "definition and standard of identity for oleomargarine" which, in addition to regulation of ingredients to insure an acceptable margarine, stipulated that when vitamin A is added, it must be in an amount not less than 9,000 U.S.P. units per pound. There have been suggestions that addition of vitamin A to margarine be made mandatory. The manufacturers, however, are doing a very good job by themselves; it has been estimated that about 90 per cent of all margarine now sold is fortified with vitamin A. Two states, Louisiana and South Carolina have passed legislation requiring that all margarine sold in these states be fortified with the required amount of vitamin A. Similarly, in England, the law requires that all margarines be vitamized with 550 units of vitamin A per ounce (8800 units per pound), and 60 units of vitamin D per ounce.

The question of whether margarine, with vitamin A added, is equal in nutritive value to butter, has received a great deal of attention for years. To all intents and purposes, margarine fortified with vitamin A is food of equal value to butter. The Food and Nutrition Board of the National Research Council (104) has stated:

> The present available scientific evidence indicates that when fortified margarine is used in place of butter as a source of fat in a mixed diet, no nutritional differences can be observed. Although important differences can be demonstrated between different fats in special experimental diets, these differences are unimportant when a customary mixed diet is used.

The above statement can only be made in respect to fortified margarine and it should be emphasized that all margarine should be fortified.

Since the inception of the margarine industry in 1874 there have been many federal and state excise and license taxes imposed upon its manufacture and sale. In some states the taxes prohibit the sale of the product and make it impossible for low income groups to obtain the fat which can be provided by margarine. Removal of all these unfair restrictions has been suggested, and some states enacted statutes suspending some of the prohibitive regulations during the war.

Flour and Bread

American diets fall below good nutritional requirements in vitamins of the B group and in certain minerals. An experiment has been conducted in which human subjects were given diets adequate except for thiamin content (105). The diets included thiamin equivalent to that provided by "poor diets" such as are consumed by about a quarter of our American Families. Previously happy, contented and industrious, these subjects became quarrelsome, lazy, depressed and indifferent. Later, the thiamin content of the diet was increased gradually without their knowledge, and as it approached the amount recommended for an adequate diet, the subjects began to regain their former cheerful, contented attitudes. Similar results might be obtained from experiments with niacin. Such deficiencies—"hidden hunger"—are doubly dangerous because they are not readily recognized. While an extreme deficiency of thiamin will cause beriberi or an extreme deficiency of niacin result in pellagra, mild deficiencies may only appear to be a case of "jitters" to an individual and will probably not be attributed to an inadequate diet.

Wheat is an excellent source of these vitamins and minerals, and as used in bread and other flour products, makes up a larger part of the total calories of the American diet than any other food. However, milling wheat to produce

white patent flour removes certain vitamins and minerals; from 86 to 90 per cent of its thiamin content and from 60 to 80 per cent of its niacin content are destroyed. Despite the campaign to influence people to use whole wheat breads, which retain most of their vitamins and minerals, over 90 per cent of all flour sold in this country has been white. Over a hundred years ago, Dr. William Buchan wrote:

> Bread is often spoiled to please the eye. The use of whitened bread, though made of the heart of the wheat, is in reality the worst of any, yet this is the bread which most people prefer, and the poorer sort will eat no other.

It is still true that the poorer classes, whose diets are made up largely of bread and flour products, take the least interest in choosing the most healthful bread and flour. Americans today consume more fresh fruits, vegetables and dairy products than did the people of Dr. Buchan's day, but the additional vitamins and minerals furnished by these foods do not entirely make up for the loss of thiamin in milling grain and from lack of this vitamin in our refined sugar. We cannot blame the millers and bakers for this state of affairs—they produce to meet a demand, and the occidental countries have come to regard white as indicative of purity—demanding white flour, white sugar and white rice. The millers have succeeded in producing a beautiful product which will make light and palatable cakes, breads and pasteries, but which is low in nutritive value.

When the Food and Nutrition Board of the National Research Council met in November, 1940, it was faced with the problem of recommending practical methods of improving the diets of millions of people in the shortest possible time. Since bread and flour products do make up such a large part of the American diet, the Committee first turned its attention to flour and bread. Dr. Robert R. Williams, who first synthesized thiamin, stated:

> No other feature of the National Nutrition Program offers this prospect of universal and immediate effect upon the nutrition of the entire

population. Enriched flour and bread can be made universal in America in six months or a year, if health leaders will unite their efforts. . . . There are comparatively few whole wheat bread eaters. We strongly recommend to the U.S. Government and to the people, the complete replacement of ordinary white bread and white flour, by enriched white bread and white flour. It is by far the most urgent and practical step that we can take toward better national nutrition.

Almost all the larger selling brands are now labelled "enriched," in fact, many housewives have come to expect all bread they purchase to be enriched. To those who have been buying these breads, the whole program of enrichment seems very natural and acceptable, but years of hard work and planning have been necessary to put this program into effect, and a great deal remains to be done before it is completely effective.

In 1939 the Council on Foods and Nutrition of the American Medical Association, after a careful study of the results of milling, made a report in which fortification of white flour was recommended. This Committee, in cooperation with the Miller's National Federation and the American Baker's Association later made such a recommendation to the U.S. Food and Drug Administration in connection with package labelling of flour and bread. The recommendations of the Food and Nutrition Board were made subsequent to these considerations. To impress upon people the fact that this program aimed at returning elements which had been removed in processing, the designation "restored" was suggested by the Board, but the name "enriched," selected because of legal implications by the Food and Drug Administration, was accepted by the Board. The Board recommended also that "enriched" flour should contain specified amounts of thiamin, niacin and iron. Riboflavin in a specified amount was optional, depending on the supply of this vitamin available. During the coal strikes, the manufacture of niacin was stopped, since it is made synthetically from a coal tar product. This far-reaching effect of a strike created a serious threat to the available supply of this vita-

min. Emphasis was placed by the Board on gaining the desired vitamin content by improving milling methods, however, since development of new methods requires time and research and the country was faced with an emergency, addition of vitamins in the synthetic form was approved.

In making the recommendations, the Board was not advocating a substitute for a *natural* food, merely the restoration of elements removed from a natural food. It did not favor the addition of other elements which do not naturally occur in wheat. Calcium and vitamin D were finally listed as optional ingredients, but only because of evidence that American diets are deficient in these elements. The Board disapproved of the addition of vitamin A, carotene and vitamin E to flour because these vitamins are more properly provided by other foods. Nor was there ever any question of the relative merits of whole wheat and enriched flour; since a majority of people prefer to eat white flour products, this was an attempt to improve white flour so that its nutritive value would compare more favorably with that of whole wheat flour.

Although some manufacturers had begun to enrich their flours and breads in January, 1942, the Administrator of Federal Security made effective the standards for enriched flour and bread. It is now illegal for a manufacturer to list claims of the vitamin and mineral content of his product unless the product specifically meets the standards set for enriched flour or bread. It also is illegal for the word "enriched" to be used unless these standards are met. Three states, Louisiana, South Carolina and Texas, led in enacting statutes forbidding the sale of white bread or flour which is not enriched. A short while later laws were passed in Alabama, Kentucky and Mississippi. In enriching white bread, bakers have the choice of using enriched flour or adding vitamins in the form of high-vitamin yeasts. A certain per cent of the vitamins are destroyed in baking, but the requirements have been set high enough to take care of this loss.

At the time the enrichment regulations were set up, critics prophesied that endorsement of this program by the government would encourage manufacturers to throw discretion to the winds and add vitamins and minerals to foods in which they were never intended to appear. There has been some tendency in this direction, but whether the flour enrichment program had any influence in this regard is questionable—manufacturers are always quick to unearth new selling points for their products and vitamins and minerals have been a "natural" for advertising and publicity staffs. The indiscriminate addition of vitamins and minerals to foods is to be deplored but will doubtless be remedied in time.

It was also pointed out by some that the vitamins of the B complex usually appear together in natural foods and that it was possible this combination is essential for maximum benefit. If this were true, addition of thiamin and niacin would serve little purpose. It has since been demonstrated, though, that milling does not destroy as much of the other vitamins of the group as had originally been supposed, therefore, with the addition of thiamin, niacin and iron, white flour comes closer to matching the nutritive value of whole wheat flour than had been anticipated.

The flour and bread manufacturers had no monetary objective when they put enriched products on the market; enrichment is not a monopoly selling point by which one company may profit; it is equally available to competitors. Enriched bread was put on the market without an increase in price; the price of flour was increased only enough to cover the actual cost of adding the vitamins and minerals. Nor was the program pushed by the manufacturers of vitamins in order to sell their products. These manufacturers were well satisfied with the sale of their products and only entered the field at the request of the proponents of flour and bread enrichment. Their cooperation, too, has been excellent; they have provided the vitamins for the enrichment of breads and flours, and at a small fraction of the price obtained for them previously. It is true that a few bakers make such vivid

claims for their enriched bread that the most deformed cripple might hope to throw away his crutches after consuming a few loaves. This is unfortunate; it was never intended that enriched flour and bread would be a cure-all for disease, but rather an aid to better and more abundant health. Bread is not a complete food in itself, nor is any other food complete for people of all ages; an adequate day's diet must include a variety of foods to furnish the nutriments required by the body.

The success of the bread and flour enrichment program today depends to a large extent on the housewife. What she demands the miller and baker will supply. Unfortunately, it is difficult for an educational campaign to reach foreign groups who can neither read nor understand English, and native-born Americans who never open a magazine or newspaper. In the southern states the hundreds of small millers who produce a cheap flour, unenriched, to compete with the more expensive, nationally known brands constitute another problem. The additional cost of adding vitamins would further reduce their profit and the families who buy these flours are concerned only with the cost, not the nutritional content. Yet it is precisely these families who need most the vitamins and minerals provided by enriched flour.

The whole grain breads and flours should be used every time in preference to white, even though the latter has been enriched. Whole wheat is the "natural" food, and contains all the elements originally present in wheat. Enriched white flour and breads (105) on the other hand, have been fortified with only two of the vitamins and one of the minerals known to have been removed during the milling process (Table 13). A great many people designate as whole wheat bread a product which is perhaps 25 per cent whole wheat flour. If the remaining white flour (75 per cent) is not enriched, these loaves offer fewer vitamins and minerals than the enriched white loaves. Nutrition workers and public health agencies should continue to advocate the whole grain breads and

flours as they have in the past, but for those who cannot or will not eat the whole grain product, enriched white bread and flour provide improved replacements.

TABLE 13

Composition of White Flour, "Enriched" White Flour and Whole Wheat Flour (105)

	White Flour	"Enriched" White Flour	Whole Wheat Flour
Thiamine, mgm. per pound	0.3	1.7	2.3
Riboflavine, mgm. per pound	0.15	1.2	0.6
Nicotinic acid, mgm. per pound	3.5	6.0	26.0
Pyridoxine, mgm. per pound	1.0	1.0	2.0
Pantothenic acid, mgm. per 100 grams	2.5	2.5	5.0
Carotene (vitamin A), mgm. per pound	nil	nil	1.5
a-Tocopherol (vitamin E), mgm. per pound	nil	nil	1.4
Fat, per cent	1.2	1.2	2.4
Protein, per cent	11.0*	11.0*	12.7†
Calcium, per cent	0.02	0.02	0.045
Phosphorus, per cent	0.092	0.092	0.423
Iron, mgm. per pound	3.0	6.0	20.0
Manganese, grams per 750 calories	0.1	0.1	6.7
Potassium, per cent	0.115	0.115	0.473
Copper, grams per 750 calories	0.40	0.40	1.6
Ash, per cent	0.37	0.37	1.70

* Low quality.

† High quality.

In time, manufacturers will perfect a method of milling which will retain a larger part of the natural vitamins and minerals, in a flour which retains the creamy color, fine texture and taste to which we are accustomed. Canada and England, as well as the United States, are vitally interested in this possibility and have developed "Canadian Approved Flour" and England's "Wheat-meal" flour. These are high in nutriments and are made from whole grain by higher-extraction milling processes. Too, some wheats contain more vitamins and minerals than others and it may be possible to grow those with the highest nutritive value in the future.

Other Foods

Improvement of other foods which lose a large part of their vitamins through processing is under consideration. Several companies are already enriching their cereal products voluntarily. Southern states have been considering the enactment of legislation requiring enrichment of corn meal and improved processing of grits (dried corn, ground) to retain their nutritive qualities. With some prosperity in the South, pellagra, resulting from a diet formerly composed principally of grits or cornmeal and fat pork, has been reduced. However, an enrichment program would go far toward eliminating the disease for all time.

TABLE 14

Effect of Treatment on Vitamin Content of Rice (106)

Name	Treatment	Thiamin	Riboflavin	Niacin
		Micrograms per gram of dry material		
Whole brown	....	3.50	0.60	60.0
White	Polished	0.60	0.28	19.0
Whole brown	Undermilled	1.22	0.32	26.0
Comet	Vitafied	3.00	0.29	18.7
Whole brown	Parboiled	1.74	0.37	40.0
Malekized—modified	Parboiled	2.00	0.40	44.0
Earle—peeled	Undermilled	3.00	0.42	50.0
Converted—modified	Parboiled	3.20	0.50	49.0

Fortification of macaroni and spaghetti has been suggested because these foods make up a large part of the diet of certain nationalities in our country, as well as in other countries. The fact that these people are not malnourished to a greater degree is probably because they eat greater amounts of organ meats (liver, kidney, etc.), which are rich in vitamins and minerals.

Rice, the beautiful white product with which we are most familiar, is another great contributor to malnutrition. In

an experiment made at the beginning of the century in the western Malay Peninsula, in which one group of laborers was fed white rice and another group brown rice (undermilled), those receiving white rice fell prey to beriberi, and those receiving the brown rice remained immune until the diets were reversed. Because polished rice makes up such a large part of their diet, beriberi still incapacitates huge numbers in the Orient. This is a very important fact to consider when we are called upon to help feed these people. However, there are areas in our own country where rice makes up a large part of the diet, and where beriberi is not uncommon. Some progress has been made in influencing manufacturers to undermill rice (Table 14) and innovations in methods of processing have permitted retention of greater amounts of vitamins in the retailed product (106).

Chapter Eight

FOOD IN ACTION

It is impossible for human beings to maintain health with one food for any length of time; they must have a variety to obtain the different substances required by the body. Indeed, Dr. C. A. Elvehjem (107), in considering the early emphasis that was placed on only measuring the caloric value of foods and the energy requirement under different conditions, likened the limited point of view "to a modern motorist who watches only the gasoline tank and pays no attention to the oil in his engine, the tires on his wheels, or the spark plugs in his cylinders." Food must nourish the body under all types of conditions and circumstances. It must furnish energy for the bodily activities, to be sure. In a humorous vain, Dr. Elvehjem further says that "many of us have learned very recently, we cannot drive our cars unless we do have gasoline." So it is that our bodies will not function without energy. But in nourishing the body foods must also provide structural materials for growth and development of the body and its component parts and to provide for maintenance and the replacements due to wear and tear. In addition, foods must furnish the substances which regulate the physiological processes of the body or provide the materials for their formation. It is in this latter phase that our knowledge of nutrition has been so greatly enhanced during the last decade. Chemical, physiological and physical research applied in studies of the nourishment of the body and life processes in general have demonstrated the dynamic nature of the body and we have learned indeed that nutrition is truly *food in action.*

Feeding—World War I

Many of the same food problems which we are now facing arose during World War I. In 1917, food was recognized

as a war weapon. Such slogans as: "Victory Does not Depend Alone on Guns and Soldiers," "An Army Marches on Its Stomach—Will you Do Your Bit?," and "The Power Behind the Gun—Sow, Save, and Serve," can be compared to those we saw and heard continuously during World War II: "Food Will Win the War and Write the Peace," "Food for Victory," "Food Fights for Freedom," and "Produce and Conserve, Share and Play Square with Food." Then, as now, our Allies looked to us for food supplies. Then, "America was the bread basket of the world," today we are looked to as "the last faint hope" of the starving slaves whose countries have been occupied by the barbarian conquerors.

With the energy concept of food as the guide to proper nutrition, emphasis in the First World War was placed on cereals, since they are the primary and cheapest sources of energy. Fats, the most concentrated fuel foods, are less plentiful and therefore expensive. Wheat for bread, and sugar were the great sources of energy food. They became critical food items very early in World War I. Campaigns were also conducted early in the war to save the supplies of meat, butter, eggs and milk. Real emphasis was placed on having the homefront do without *white* flour and bread to make it available for the soldiers. Recipes to save wheat resulted, giving birth to the so-called "liberty breads"—breads with only part white flour, or no white flour. Recipes for cakes and cookies substituted a fourth of other flours for white. "Patriotic desserts" were designed to use a minimum of wheat, sugar, butter and eggs. An outstanding example was the sugarless, eggless, butterless cake. This emphasis upon food as fuel for the body machine is best illustrated by the food groupings recommended by the Department of Agriculture (108):

Group I—For mineral matters, vegetable acids and body-regulating substances: fruits and vegetables.

Group II—For protein, for muscle-building: milk, eggs, meat, poultry, fish, dried peas, and beans, and nuts.

Group III—For starch: cereal grains, meals, flour (with emphasis on substituting rye, rice, barley, oats and corn flours for wheat). Cereal breakfast foods. Bread, crackers, macaroni and other pastes, cakes, cookies and starchy puddings. Potatoes and other starchy vegetables.

Group IV—For sugar: sugar, molasses, syrup and honey; candies, preserved fruits, sweet cakes and desserts.

Group V—For fat: butter and cream, lard, suet and other cooking fats; salt pork and bacon; and table and salad oils.

When we entered World War I, our knowledge of food requirements in relation to the nutrition of the body had progressed far enough to interest the army command. At that time it was well established that the physical laws of the conservation of energy applied to the human body as well as to the steam engine. We took in food; we breathed in oxygen. In the cells of the body the food elements were combined with the oxygen to yield energy and permit work. We breathed out carbon dioxide through the lungs and eliminated the residues through the kidneys and intestines. The fuel value of different foods could be measured in terms of heat units or calories. The volume of oxygen breathed in and the volume of carbon dioxide expelled could be measured. The actual amount of heat produced by the body could be measured in terms of these same heat units—calories. A balance sheet could be made and the energy requirements of the body defined in terms of calorie units of food. The body, like the engine, required fuel to produce work and the more work, the more fuel required.

It was also recognized that all foods did not contain the same amount of energy, that one ounce of fat would furnish over twice the amount of heat or number of calories when burned in the body than one ounce of sugar. In addition to differences in energy values of foods, it was known also that foods were different in their ability to furnish the body with protein (amino acids), the building material of tissue. The animal body could grow and remain healthy on certain protein foods such as milk, meat and eggs, whereas on vegetable proteins alone it would stop growing and lose

weight. Further, it was known that fresh fruits and vegetables contained special substances not found in dried or canned foods and that fats, like butter, contained materials not found in vegetable oils and lard. These substances were called vitamins, but more than this no one could say—what they were or why they were needed by the body.

Feeding—World War II

The concept of the role of food today, however, is very different from that of 1917. In the interim between the two wars the world witnessed one of our greatest scientific advances. The infant bud, nutrition, blossomed into the full flower of adolescence. Today, we do not have the fear of wheat scarcity, we do not need to fuss about a sugar shortage. We are concerned with quality first—it is just as important, and possibly more, to satisfy the hidden hunger as well as the hollow hunger. The very fact that during a quarter-century we advanced so tremendously in our knowledge of nutrition has helped us to prevent food shortages in that now we can use our foods more wisely and economically. The deficiencies of the past were not human errors; they resulted from lack of knowledge. Today we have knowledge. Failure to use it would be not only a waste of good and needed food supplies, but a catastrophic blow to our national health.

No better example of the great strides the science of nutrition made in the intervening 25 years can be given than to compare the food groupings of the First World War, those just given, with those emphasized in its sequel. The official wartime nutrition chart emphasized seven basic food groups and the slogan "U.S. Needs Us Strong—Eat the Basic 7 Everyday." First eat what you need, then eat what you want—this is the modern precept of the newer knowledge of nutrition by which, if followed, we may obtain buoyant health from the foods we eat.

In comparing the Basic 7 food groups with the earlier 5 groups it is well to emphasize that we had no new foods.

The same foods are still with us, fortunately, and all were included in both lists, but emphasis has been placed on meeting the nutritive requirements of the body rather than on substituting corn and oats, or syrup and honey, for wheat or sugar. Probably the most impressive demonstration of the change in attitude has occurred with white bread. Ironically, in the first war, we thought we were doing the fighting men of the nation a favor by sacrificing our *white* flour and bread on the homefront so that no soldier should have to eat the so-called "black" breads. We shipped to the fighting fronts the nutriment-deficient white bread and flour, and soothed the injury to our cultivated appetite with the patriotic salve of eating the more-nutritive "black" bread. In our ignorance, we took great pride in this sacrifice for patriotism. Fortunately, nutrition research during the two decades disspelled much of the darkness surrounding our knowledge of the function of foods. Group I of the original five blossomed into three groups of the Basic 7. Instead of fruits and vegetables under one group we have now:

Group I—Green and yellow vegetables; some raw—some cooked, frozen or canned.

Group II—Oranges, tomatoes, grapefruit; or raw cabbage or salad greens.

Group III—Potatoes and other vegetables and fruits; raw, dried, cooked, frozen or canned.

Group II of 1917 was split into two groups in 1943:

Group IV—Milk and milk products, fluid, evaporated, dried milk, or cheese.

Group V—Meat, poultry, fish, or eggs; or dried beans, peas, nuts or peanut butter.

Group III of World War I—the starch foods—became Group VI:

Group VI—Bread, flour, and cereals; natural whole grain—or enriched or restored.

Notice that the "dark" or whole grain breads are recommended. If you can't eat these, you can still "have your

cake and eat it too." You may indulge a perverted palate and obtain *some* of the nutriments lost through milling by eating the enriched, fortified or restored white breads.

The fourth group of the original five—sugar or sweets—has been discarded from the new list. The American public had so cultivated and indulged its "sweet tooth" that it was fast becoming a "national nutrition scandal." The Greeks were noted for their teachings and American citizens are the

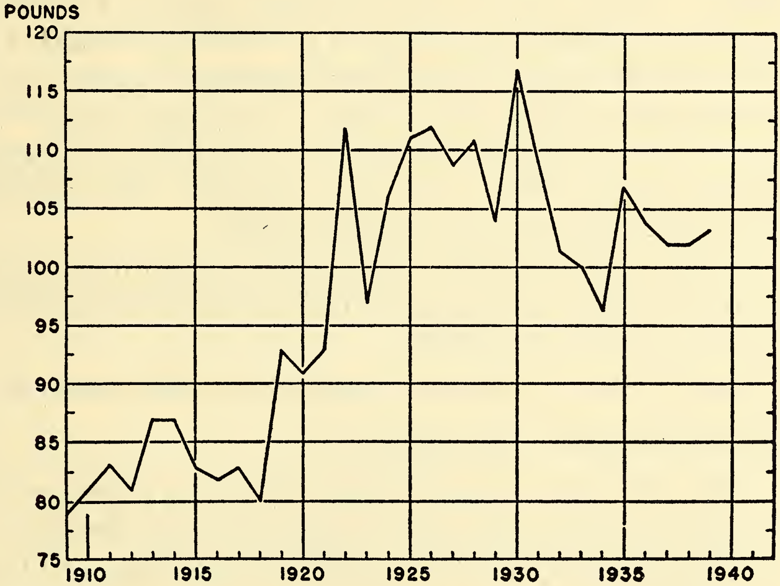


Fig. 9. Per capita consumption of cane and beet sugar, raw basis, in the United States, 1909–1939 (75).

recipients of a system of universal education but "moderation in all things" was apparently not translated into our language. We average nearly twice the yearly per capita sugar consumption of any other group of people. Stiebeling's (75) figures show that at the time of World War I we were consuming an all time high of pure sugar of over 90 pounds per person annually. The peak in sugar consumption occurred in 1930 (Figure 9). At the beginning of World War II sugar consumption was still over 100 pounds per year, representing on the average, about one-seventh of our total food calories. Refined sugar is an unessential in our diet but we have gone

along blithely crowding essential nutriments out of our diet by over-consumption of sweets and ignoring the danger to our teeth and increased probability of diabetes in later life, as well as to our waist-lines.

The rubber shortage brought this latter phase of our national indulgence to light. The great outcry for foundation garments showed that many women prefer torture from an elastic straight-jacket to wise restriction of unnecessary calories. It has taken strong publicity, backed by masses of scientific evidence appealing to the desire for health and vitality, to discourage this national pastime of eating excessive amounts of high-calorie foods. The battle is far from won, but is progressing despite the frothings of special pressure groups who seek only economic and political privilege at the expense of national health.

Finally, the last of the original five groups has become Group VII of the new list, unchanged except for the specification of "fortified" margarine.

Group VII—Butter and fortified margarine (with added vitamin A).

Recommended Dietary Allowances

When the Food and Nutrition Board was organized its first major problem was to set up a "Nutrition Yardstick" whereby the adequacy of diets could be determined. At that time this information was needed to determine allowances to be made for army and navy diets, for lend lease relief, and for rationing standards which would assure a good civilian diet. The task was a difficult one, owing to the lack of sufficient experimental evidence, with human beings, on which to base requirements. There were differences of opinion among the experts, but after careful study of the literature, and consultation among the nutrition authorities, a chart of *Recommended Dietary Allowances* for specific nutriments was developed. While every nutritionist might not agree on the amount of each nutriment recommended, they were all willing to accept these figures tentatively, or until future experimentation definitely showed that they should be altered.

Since these Recommended Dietary Allowances represent the composite judgement of the best authorities on the subject, viewed in the light of our present knowledge, we have reproduced them as published by the National Research Council (109). [To convert the weights given in the table in kilograms (kg.) to pounds, multiply by 2.2; to convert those in grams (gm.) to avoirdupois ounces multiply by 0.0353.]

Recommended Dietary Allowances

Food and Nutrition Board, National Research Council

"Dietary standards to serve as a goal for good nutrition and as a "yardstick" by which to measure progress toward that goal have long been needed. In 1935 the League of Nations made a concerted group effort to formulate such a yardstick. One of the first concerns of the Food and Nutrition Board (formerly the Committee on Food and Nutrition of the National Research Council), established in 1940 to advise on nutrition problems in connection with National Defense, was to define in accordance with newer information the recommended daily allowances for the various dietary essentials for people of different ages.

"The difficulty in such an undertaking lies in the lack of sufficient experimental evidence on which to estimate requirements for the various nutrients with any great degree of accuracy. Judgments as to requirements are necessarily based on incomplete and often conflicting reports of research and clinical observations and on data derived from work on animals. Experiments with the various vitamins also differ with regard to procedure and interpretation. These variables explain the wide divergence in "requirements" as set forth in current literature on nutrition.

"In view of the confusion caused by this great variation in standards used, it seemed desirable to attempt to derive a table of allowances which would represent the best available evidence on the amounts of the various nutritive essentials to include in practical diets. With this aim in view, the

2.2
70
154.0#

TABLE 15

RECOMMENDED DIETARY ALLOWANCES*

Food and Nutrition Board, National Research Council

	Calories	Protein grams	Calcium grams	Iron mg.	Vitamin A† I.U.	Thiamin (B) mg.‡	Ribo-flavin mg.	Niacin (nicotinic acid) mg.	Ascorbic acid mg.‡	Vitamin D I.U.
Man (70 Kg.)										
Sedentary	2500	....	...	..	....	1.5	2.2	15		
Moderately active	3000	70	0.8	12	5000	1.8	2.7	18	75	¶
Very active	4500	....	...	..	....	2.3	3.3	23		
Woman (56 Kg.)										
Sedentary	2100	....	...	..	....	1.2	1.8	12		
Moderately active	2500	60	0.8	12	5000	1.5	2.2	15	70	¶
Very active	3000	....	...	..	....	1.8	2.7	18		
Pregnancy (latter half)	2500	85	1.5	15	6000	1.8	2.5	18	100	400 to 800
Lactation	3000	100	2.0	15	8000	2.3	3.0	23	150	400 to 800
Children up to 12 years:										
Under 1 year§	100 per kg.	3-4 per kg.	1.0	6	1500	0.4	0.6	4	30	400 to 800
1–3 years‖	1200	40	1.0	7	2000	0.6	0.9	6	35	¶
4–6 years	1600	50	1.0	8	2500	0.8	1.2	8	50	
7–9 years	2000	60	1.0	10	3500	1.0	1.5	10	60	
10–12 years	2500	70	1.2	12	4500	1.2	1.8	12	75	
Children over 12 years:										
Girls, 13–15 years	2800	80	1.3	15	5000	1 4	2.0	14	80	¶
16–20 years	2400	75	1.0	15	5000	1.2	1.8	12	80	
Boys, 13–15 years	3200	85	1.4	15	5000	1.6	2.4	16	90	¶
16–20 years	3800	100	1.4	15	6000	2.0	3.0	20	100	

* Tentative goal toward which to aim in planning practical dietaries; can be met by a good diet of natural foods. Such a diet will also provide other minerals and vitamins, the requirements for which are less well known.

† Requirements may be less if provided as vitamin A; greater if provided chiefly as the pro-vitamin carotene.

‡ 1 mg. thiamin equals 333 I.U.; 1 mg. ascorbic acid equals 20 I.U.

§ Needs of infants increase from month to month. The amounts given are for approximately 6–8 months. The amounts of protein and calcium needed are less if derived from human milk.

|| Allowances are based on needs for the middle year in each group (as 2, 5, 8, etc.) and for moderate activity.

¶ Vitamin D is undoubtedly necessary for older children and adults. When not available from sunshine, it should be provided probably up to the minimum amounts recommended for infants.

Further Recommendations, Adopted 1942:

The requirement for *iodine* is small; probably about 0.002 to 0.004 milligram a day for each kilogram of bodyweight. This amounts to about 0.15 to 0.03 milligram daily for the adult. This need is easily met by the regular use of iodized salt; its use is especially important in adolescence and pregnancy.

The requirement for *copper* for adults is in the neighborhood of 1.0 to 2.0 milligrams a day. Infants and children require approximately 0.05 per kilogram of body weight. The requirement for copper is approximately one-tenth of that for iron.

The requirement for *vitamin* K is usually satisfied by any good diet. Special consideration needs to be given to newborn infants.

Physicians commonly give vitamin K either to the mother before delivery or to the infant immediately after birth.

literature on the subject of each of the dietary essentials was critically appraised, and in addition judgments as to the various requirements were solicited from a considerable number of nutrition authorities in addition to members of the Board, especially those whose research bore particularly on the problem. On the basis of this evidence tentative allowances were formulated. These were resubmitted to contributors for criticism and reformulated in the light of the comments made. The values thus revised were presented before a section meeting of the American Institute of Nutrition in 1941 and members invited to submit further evidence for any changes that seemed indicated. After final discussion and some minor revisions they were adopted by the Board in May, 1941. The values as presented thus represented the combined judgment of more than fifty persons qualified to express an opinion on the subject. This does not mean, of course, that every contributor would fully agree with all the figures as given. It does mean, however, that the values are ones they were willing to accept tentatively, until standards derived from more extensive and exact research data can be obtained. The term "Recommended Allowances" rather than "Standards" was adopted by the Board to avoid any implication of finality.

"In using these recommendations, it is important that the purpose and general policies in formulating them should be understood:

What the Allowances Provide

"The allowances for specific nutrients are intended to serve as a guide for planning adequate nutrition for the civilian population of the United States. The quantities given were planned to provide not merely the minima sufficient to protect against actual deficiency disease but a fair margin above this to insure good nutrition and protection of all body tissues. Since the actual requirements for these purposes are not known it is recognized that the margins of safety may vary considerably for the different factors. The Board

realizes that the values proposed will need to be revised from time to time as more knowledge of nutritive requirements becomes available.

No Allowances for Losses in Cooking

"It should be pointed out that the vitamin figures are calculated requirements for food as eaten and do not allow for losses in cooking. Since such losses may be extensive, especially of the water-soluble vitamins, provision should be made for them in planning practical dietaries.

Other Factors for Which Allowances Are Not Given

"In addition to the three factors of the B complex included, other members of the group, such as vitamin B_6 and pantothenic acid, should be given consideration. But at the present time no specific values can be given for the amount required in the human dietary. It should be added, however, that foods supplying an adequate amount of thiamin, riboflavin, and niacin (nicotinic acid) will tend to supply an adequate amount of the remaining B vitamins. Similarly diets providing adequate amounts of protein, calcium, and iron will tend to supply other needed minerals, though these are not listed. There is urgent need for continued research on the requirements for all dietary essentials, especially for children.

Allowances Based on Average Size, Sex, and Activity for Normal Individuals

"The allowances for adults are given for the 70 Kg. man and the 56 Kg. woman at three levels of activity. They will need to be proportionately increased or decreased for larger or smaller individuals. It will be noted that the allowances for thiamin, riboflavin, and niacin (nicotinic acid) are proportional to the caloric intake. This relationship has been established for thiamin, and it has been assumed to hold also for riboflavin and nicotinic acid since, like thiamin, they are

part of the enzymic system involved in the metabolism of carbohydrate.

"The allowances for children are given by age groups, and for boys and girls separately after 12 years, since from that age the growth curves and levels of activity for the two sexes differ. The values presented are in each case for the middle year in the group, and represent amounts needed for children of average size and activity. The needs for individual children may be proportionately larger or smaller depending upon size and activity.

"It is to be understood that these allowances are for persons in health, and that needs may vary markedly in disease. For example, in febrile conditions there is usually an increased need for calories, thiamin and ascorbic acid. The need for these or other constituents may also be greatly altered in other diseases, especially those of the alimentary tract, which interfere with normal absorption.

Slight Changes in 1941 Allowances

"Recommendations as adopted in 1941 remain substantially unchanged at this writing—approximately two years after the initial compilation of data.

"Consideration has been given to three more nutrients not covered in the original recommendations. They are iodine, copper and vitamin K. Recommendations for these substances are now included for the first time in this summary.

Diet Plans that Meet the Dietary Allowances

"In using the recommended allowances it should be emphasized that the amounts of the various nutrients provided for in these recommended allowances, with the exception of vitamin D can be obtained through a good diet of natural foods including foods like enriched white flour and bread which have been improved according to recommendations of the Board.

"The safest way to insure that the dietary allowances are met is to include certain foods in the diet daily in specified

amounts. One dietary pattern which contains a variety of foods commonly available is given below:

List I

Milk	1 pint
Egg	1 daily, if possible. (On days not used, beans, peanuts, cheese, or more milk or meat to be used instead)
Meat, fish or fowl	1 or more servings
Potato	1 or more
Vegetables	2 or more servings. One green or yellow
Fruits	2 or more. One citrus fruit or tomato or other good source of vitamin C
Cereals and bread	Whole-grain or enriched

Other foods as needed to complete the meals.

"This list is based on the needs of the average adult. For children the milk needs to be increased but the kinds of foods to include remain the same.

"Another list using less milk and lean meat is given as illustrative of the varied ways in which the allowances may be met.

List II

Turnip greens	1 cup
Sweet potatoes	3
Peanuts	20 nuts or 2 tablespoons of peanut butter
Beans or cowpeas	$1\frac{1}{2}$ oz.
Tomatoes	1 cup
Corn meal	3 oz.
Enriched flour	3 to 4 oz.
Milk (fresh, evaporated or dried)	$\frac{1}{3}$ qt.
Lean pork	small serving 3 to 4 times a week

Molasses, fat, etc., to complete the meals

"Calculations show that both these lists meet the dietary allowances. It should be pointed out, however, that every food is needed in the amounts specified. If any food is omitted, therefore, it should be replaced by another of equal value.

Nutrition of the American Medical Association and of the Food and Nutrition Board of the National Research Council prepared a series of food charts (110) which show how average servings of various common foods contribute to meeting the different chemical requirements of the body:

Protein

Those who are called upon to give advice concerning ways of securing an adequate diet must recognize the importance

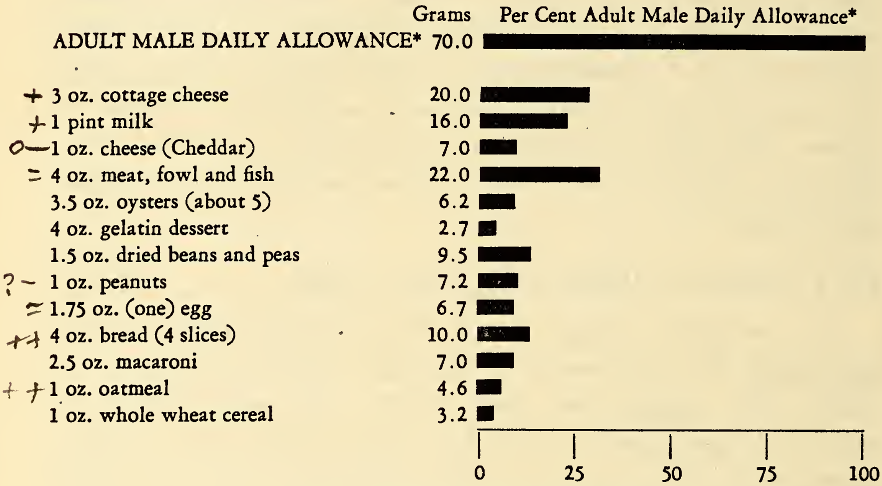


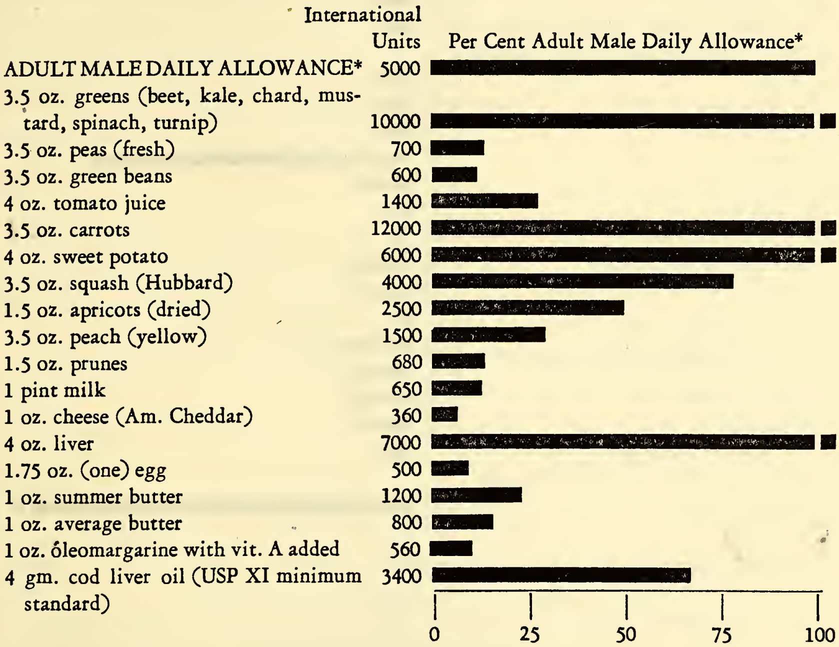
Fig. 10. Foods as sources of proteins.†

* Recommended by the Food and Nutrition Board of the National Research Council.

† Adapted from a chart prepared by a Joint Committee of the Council on Foods and Nutrition of the American Medical Association and of the Food and Nutrition Board of the National Research Council (110).

of the protein allowance. Groups who are obliged to consume much cereal should be advised to utilize a wide variety of cereals and vegetables. Proteins individually inadequate, if not deficient in the same essential amino acids, will supplement one another in the diet. Also, the economic advantage of fortifying a cereal diet with at least some of the more expensive but well-balanced proteins of meat, egg and milk should be pointed out. Whenever possible, a selection of at least 40 per cent of the protein intake should be made from animal sources. This practice has been widely recommended

as a means of insuring good balance in amino acid supply, although evidence may show lesser amounts are necessary. Milk, meat and eggs are particularly important because of their excellent amino acid mixtures, specific minerals and vitamins. A portion of the food dollar is economically and wisely spent, irrespective of cost, when used to purchase



600
4000
2000
650
1000
500
110
13460

FIG. 11. Foods as sources of vitamin A.†

* Recommended by the Food and Nutrition Board of the National Research Council.

† Adapted from a chart prepared by a Joint Committee of the Council on Foods and Nutrition of the American Medical Association and of the Food and Nutrition Board of the National Research Council (110).

milk, eggs and meat. In no locality are these foods so expensive that we can afford to class them as luxury items.

Milk is naturally elaborated for nourishment at a time when requirements for growth are at a maximum and would be expected to contain Nature's amino acid provisions for the young of a given species. The casein content of cow's milk is almost eight times that of human milk. The whey contents of the two milks are similar. Whey protein, as a source of seven amino acids, is equivalent to the casein

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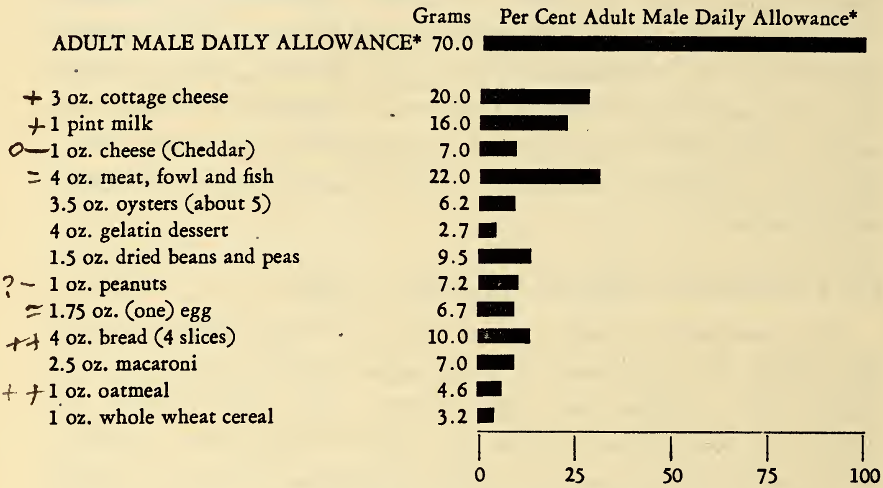

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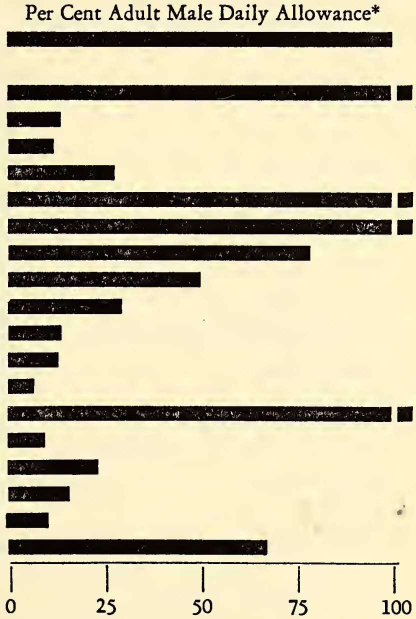
		International Units	
	ADULT MALE DAILY ALLOWANCE*	5000	
	3.5 oz. greens (beet, kale, chard, mustard, spinach, turnip)	10000	600
? —	3.5 oz. peas (fresh)	700	
+	3.5 oz. green beans	600	
.	4 oz. tomato juice	1400	
+	3.5 oz. carrots	12000	4000
+ +	4 oz. sweet potato	6000	2000
+	3.5 oz. squash (Hubbard)	4000	650
? —	1.5 oz. apricots (dried)	2500	1000
—	3.5 oz. peach (yellow)	1500	500
+	1.5 oz. prunes	680	110
+	1 pint milk	650	
? —	1 oz. cheese (Am. Cheddar)	360	
+	4 oz. liver	7000	13460
+	1.75 oz. (one) egg	500	
? —	1 oz. summer butter	1200	
? +	1 oz. average butter	800	
? +	1 oz. ôleomargarine with vit. A added	560	
	4 gm. cod liver oil (USP XI minimum standard)	3400	



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fraction and this by-product of cheese and other processed foods and of commercial casein used in paints, coatings and plastics is now discarded in large quantities when it could

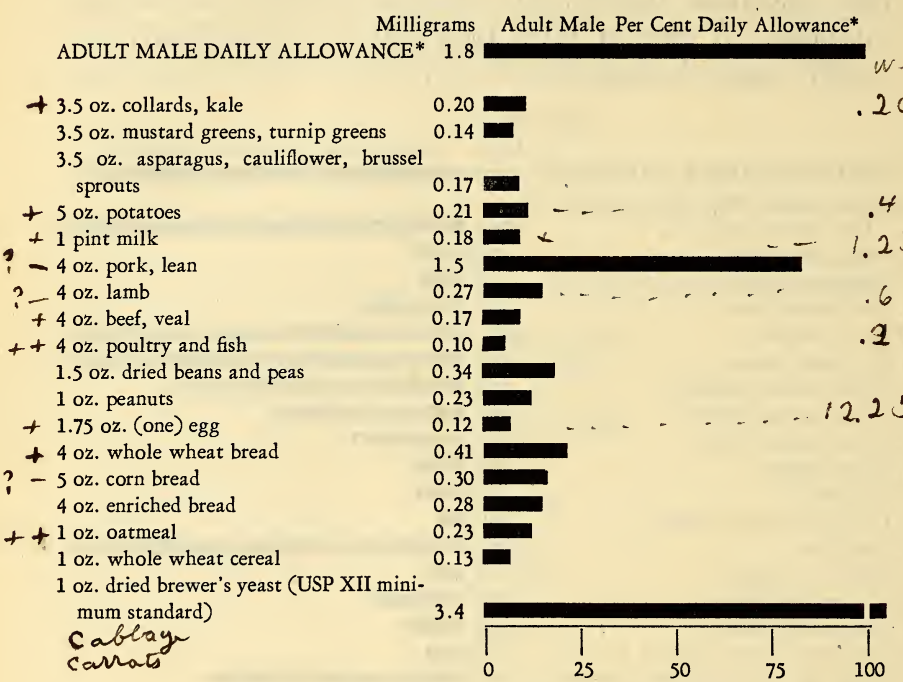

Fig. 12. Foods as sources of thiamin (vitamin B_1).†

* Recommended by the Food and Nutrition Board of the National Research Council.

† Adapted from a chart prepared by a Joint Committee of the Council on Foods and Nutrition of the American Medical Association and of the Food and Nutrition Board of the National Research Council (110).

serve as a great reservoir of valuable amino acids, minerals and vitamins.

Vitamin A

Liver is an excellent source of vitamin A. Green and yellow vegetables in proper amounts will assure an ample intake of vitamin A, or of carotene which is converted into the vitamin by the body. With a good, mixed diet containing dairy products and green and yellow vegetables the healthy person will receive ample amounts of vitamin A.

Thiamin

The outstanding food source of thiamin is pork. Other foods contain far less of this vitamin and a diet must be selected carefully to assure adequate amounts, especially for children and for women during pregnancy and lactation. Studies of the average 2500 calorie American diet (43) show thiamin is furnished in the following proportions from the different food groups: 24 per cent from cereals; 21 per cent from dairy products; 26 per cent from meat; 21 per cent from vegetables; 9 per cent from fruit.

Riboflavin

The average American diet furnishes riboflavin in the following proportions from the basic food groups (111): 49

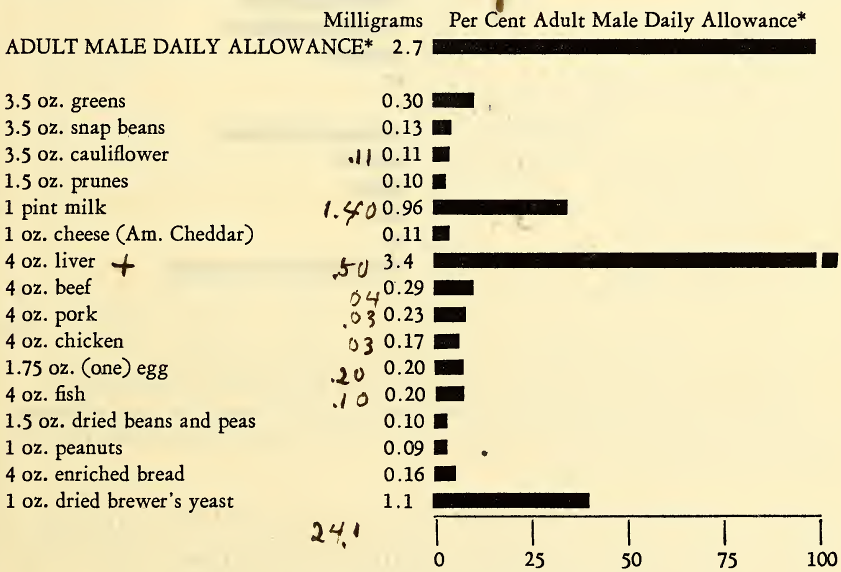

FIG. 13. Foods as sources of riboflavin (vitamin G).†

* Recommended by the Food and Nutrition Board of the National Research Council.

† Adapted from a chart prepared by a Joint Committee of the Council on Foods and Nutrition of the American Medical Association and of the Food and Nutrition Board of the National Research Council (110).

per cent from dairy products; 19 per cent from meat, poultry and fish; 18 per cent from cereal products, enriched; 10 per cent from vegetables; 3 per cent from fruit.

Niacin

Information concerning niacin in foods and the requirement for it is still limited but diets which furnish adequate protein intakes with one-half of the protein of animal origin would supply ample amounts of the vitamin. The average American diet includes niacin (111): 59 per cent from meat,

		Milligrams
ADULT MALE DAILY ALLOWANCE*		18.0
5 oz. potato	1.60	1.6
3.5 oz. carrots	1.50	1.5
4 oz. yam	.1	0.8
1 pint milk	.4	0.3
4 oz. liver	4.0	18.0
4 oz. beef	1.0	7.5
4 oz. pork		6.0
4 oz. poultry	1.1	7.7
4 oz. salmon		8.4
1 oz. peanuts		3.6
1.5 oz. dried beans and peas		0.9
1.75 oz. (one) egg	.03	0.03
1 oz. bran		8.8
4 oz. whole wheat bread	1.5	3.3
4 oz. enriched bread		2.5
1 1 oz. whole wheat cereal	3.6	1.8
5 oz. corn bread		0.9
1 oz. dried brewer's yeast		11.4

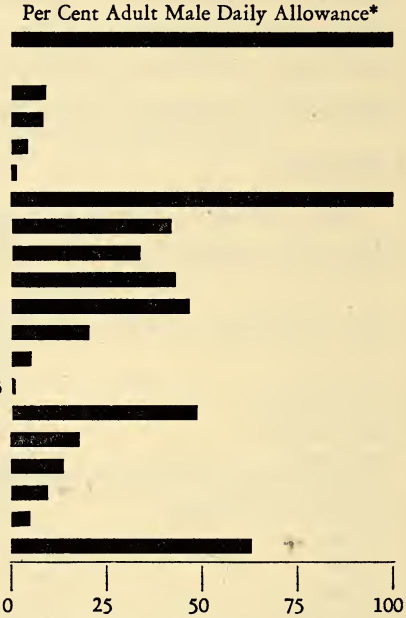

FIG. 14. Foods as sources of niacin (nicotinic acid).†

* Recommended by the Food and Nutrition Board of the National Research Council.

† Adapted from a chart prepared by a Joint Committee of the Council on Foods and Nutrition of the American Medical Association and of the Food and Nutrition Board of the National Research Council (110).

poultry and fish; 17 per cent from cereal products, enriched; 17 per cent from vegetables, including potatoes; 2 per cent from milk and dairy products; 3.2 per cent from fruit.

Ascorbic Acid

While citrus fruits contain the largest amounts of ascorbic acid many other fruits and vegetables are excellent sources, some of them being far less expensive. Adequate amounts of vitamin C may be included in a diet without added cost by

using foods such as cabbage, sweet potato and turnips which have high energy values as well as ascorbic acid contents. Notwithstanding its widespread occurrence and low cost, many Americans do not receive sufficient amounts of this

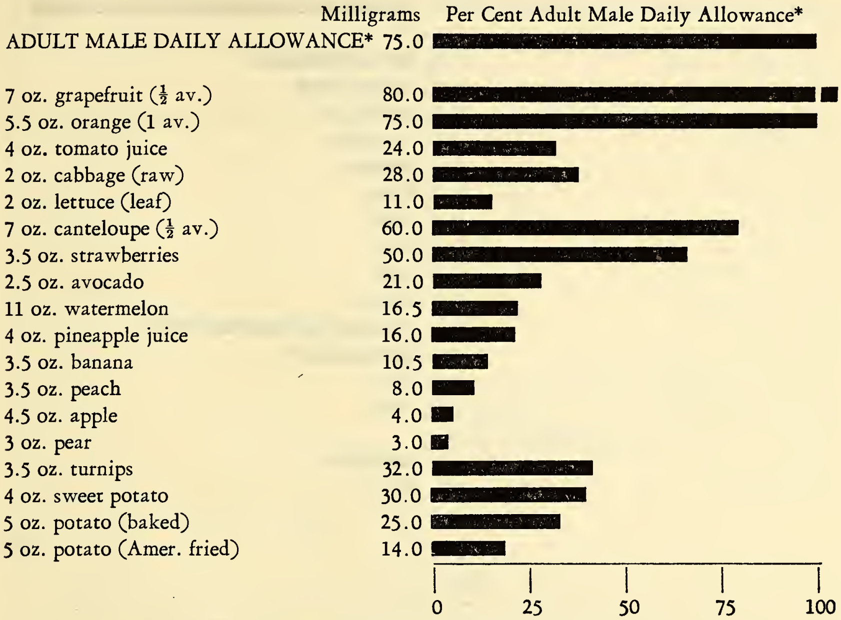

FIG. 15. Foods as sources of ascorbic acid (vitamin C).†

* Recommended by the Food and Nutrition Board of the National Research Council.

† Adapted from a chart prepared by a Joint Committee of the Council on Foods and Nutrition of the American Medical Association and of the Food and Nutrition Board of the National Research Council (110).

vitamin, although cases of actual scurvy are rare in this country.

Calcium

The importance of calcium in the diet cannot be overemphasized. The mineral needed in the greatest amounts in the body, calcium can be supplied by only a limited number of foods and without milk it would be difficult to meet the demands of the growing child or the pregnant or lactating woman. Certain vegetables, such as beet greens and spinach, contain calcium in the form of calcium oxalate, which tends to reduce calcium utilization. However, these

vegetables are not given for their calcium alone, for these green vegetables carry vitamins and other minerals. The presence of vitamins C and D in the diet is essential in calcium

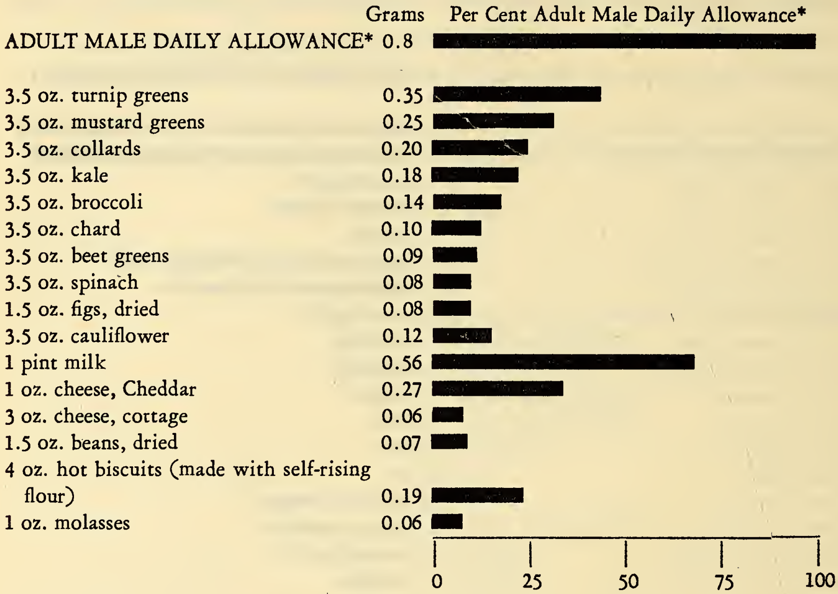

FIG. 16. Foods as sources of calcium.†

* Recommended by the Food and Nutrition Board of the National Research Council.

† Adapted from a chart prepared by a Joint Committee of the Council on Foods and Nutrition of the American Medical Association and of the Food and Nutrition Board of the National Research Council (110).

utilization; similarly, there are optimal levels of phosphorus and fat intakes, in relation to the calcium consumed, which permit the calcium to be more completely utilized.

Iron

Ordinarily, diets composed with a variety of foods including meats, legumes and green leafy vegetables provide adequate amounts of iron.

Meeting the Recommended Allowances for the Family

With the recommended allowances as a guide, the Federal Government has inaugurated a program which seeks to educate everyone in the advantages of eating an adequate

diet. Nutritional campaigns are not new. During World War I Germany was forced to sponsor an educational campaign to conserve food after imports had been cut off by the allied blockade. In this country, educational material was published on good nutrition, dietetic advice given, and wartime cook books supplied. Emphasis during the earlier war,

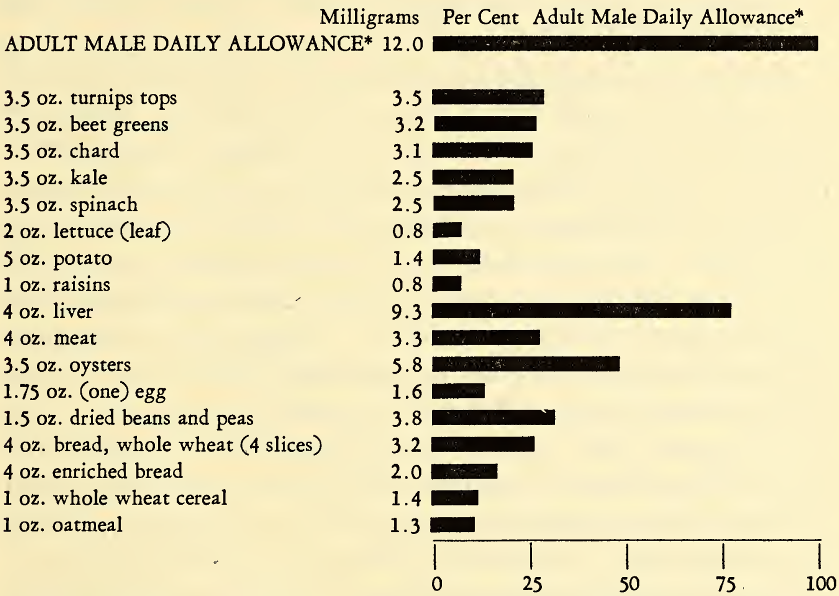

Fig. 17. Foods as sources of iron.†

* Recommended by the Food and Nutrition Board of the National Research Council.

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however, was on "saving food" and on the amount of calories consumed, rather than the nutritional adequacy of the diet. Thus, in 1917, Graham Lusk (112) listed the following propositions:

1. Eat corn bread and save the wheat for France, the home of Lafayette, and for our other allies.
2. Let no family (of five persons) buy meat until it has bought three quarts of milk.
3. Save the cream and butter and eat vegetable oils and oleomargarine.
4. Eat meat sparingly, rich and poor, laborer and indolent alike.
5. If fat, grow thin.

6. Be a prohibitionist for the period of the war (if you have enough resolution).
7. Save everything that can be used for food, because food is precious.
8. Finally remember that all the world is seeking for food-fuel with which to do work and that, though our wheat crop is short, still we are the nation most richly endowed with food-fuel, it remains to be seen whether we have the intelligence to fitly utilize for the welfare of mankind the resources which God and Nature have placed in our hands.

In the final analysis, the housewives hold the health of the nation in their hands—it is here that the science of nutrition is applied. There are few women, though, who have the time or inclination to compute each day how many milligrams of thiamin are included in one day's meals served her family. For this reason, nutrition workers in the field have been asked to translate these recommendations into practical food servings and meals. A great many companies and organizations have set up practical charts based on the *Recommended Dietary Allowances*, for use in the home. For this purpose the selection of vegetables is practically unlimited, provided it includes both green and yellow ones, and they may be prepared in any way desired, boiled, creamed or raw in salads. Likewise, with eggs and milk products it is not suggested that we sit down and eat a poached or boiled egg each day, or drink a pint of milk. These may be used in a variety of prepared dishes such as puddings and ice cream, cream soups and vegetables, or souffles. Nor does it mean that people who are unable to eat certain foods because of religious beliefs or customs must necessarily be receiving an inadequate diet. For instance, any kind of meat may be served—beef, pork, lamb, veal, fish, poultry—or eggs may be substituted and an adequate diet still be maintained. This is also an important consideration when housewives are doing their best to stretch the food dollar.

In different sections of the country the products available vary. In some sections, notably some parts of the South, planning an adequate diet presents a real problem because of the limited variety of foods available. Dietitians and public

health agencies in the field, however, are attacking the problem by setting up practical diets from products available, and making suggestions for substitutes. Temporary difficulties have arisen from scarcities of individual foods, but usually these can be overcome by using other foods. In one locality meat may be scarce at one time or another and plentiful at others. Butter, eggs, milk or any other commodity may vary in availability, with its distribution temporarily disturbed by seasonal demands, transportation difficulties, crop failure or disease among local livestock.

There is an increasing awareness among the housewives of America of the importance of food in our daily lives. We are learning first hand that simple, carefully selected, inexpensive and plentiful foods may be successfully made into nutritious, tasty and varied menus which are attractive, satisfying and healthful. In four years of war Britishers learned that health and vigor can be maintained and often improved without many of the varieties and expensive foods to which they were formerly accustomed. They applied the newer knowledge of nutrition and have substituted foods intelligently, thereby protecting the health of the nation.

Authorities assure us that there will be *Food Enough* (70) despite the difficulties arising from distribution and food wastage. Dr. Russell M. Wilder, former Chairman of the Food and Nutrition Board and former Chief of the Civilian Branch of the War Food Administration assures us that we can increase the food supply by finding more foods that are not now used for human consumption. Changes in eating habits may be involved but not starvation, nor "hidden hunger." He states (113) that:

> The study of the science of nutrition and of agricultural economics has shown the way to make great shifts in food production in the interest of economy without sacrificing the nutritional values of the total food supply. Production costs for certain foods are low, for others they are high. By shifting to the low cost foods and using no more manpower or equipment than is now at hand, far more of all essential nutrients can be produced than now. Conservative shifting could increase our food sup-

plies by 40 per cent in a year or two. Somewhat more radical changes would enable present resources to support a population twice as large as that we now support. . . .

The foods produced would include those that can be produced economically in terms of land, manpower and equipment. The main increase in production would be in milk, butter, eggs, grains, peas, beans, soybeans, peanuts, vegetable fats, whereas the decreases in production would be in beef and hogs, except those that can be raised almost exclusively on pasture; in poultry except those used in egg production; in fruits and vegetables, other than a selected list of these based on unusual nutritional value or relative non-perishability.

The problems of the culinary head of the household are not solved when the proper foods are purchased. The foods must reach the table and be eaten without extensive changes in their nutritive value. Nutriments may be wasted by the methods of handling the food preliminary to cooking. Removing and discarding the skins of certain fruits and vegetables may cause serious losses of nutriments whereas in others the depreciation of the nutritive value of the foodstuff is not so great. Allowing prepared vegetables to stand in water before cooking causes losses of vitamins and minerals. The iron content of vegetable leaves is greater than that of the stems. Ascorbic acid is found in greater concentration in the upper part of broccolli and rhubarb stalks. Bruised tissues and cut surfaces of various kinds of fruits and vegetables permit exposure to air and therefore a reduction in the ascorbic acid content. Varying amounts of minerals and vitamins may both be lost when preparing fruit and vegetable juices, and the pulp such as found in tomato juice is as nutritious as the clear liquor.

Chapter Nine

FOOD FOR WORK

When we entered World War II, the race was against time to train sufficient numbers of men and to produce enough implements of war, not only to stem the tide, but to turn it in our favor. It was imperative that we utilize every known method, and devise new methods, of increasing production so that every hour of every American's time could be used to the fullest advantage. Under these conditions, more was accomplished in promoting adequate nutrition than in ten years of peace. Germany for years had been aware of nutrition as the determinant in development of the capacity to do work and to work efficiently, whether as a soldier or factory worker, and had eight men engaged in producing and handling food for every fighting man. Japanese scientists had worked 20 years on compounding concentrated diets for her armies of aggression. England, desperately fighting for her very existence long before we entered the war, furnished us with records of valuable experience in furthering the nutrition of workers in both the military and production forces.

In modern warfare a nation cannot be divided into those who fight and those who do not. Every person doing a necessary job—the soldier, sailor, marine; munitions worker, miner, farmer; research worker, teacher, housewife—contributes to the prosecution of the conflict and participates in achieving victory. The First World War provided the stimulus for the initial large-scale attempts to apply the science of nutrition. At that time the science was young, its knowledge limited, and its protagonists few. But out of the experience with feeding the A.E.F. of 1916 came information which speeded the development of nutritional science, consolidating the information available and coordinating the endeavors of its disciples. Until the world

struggle was resumed, nutrition was given few opportunities to demonstrate its value outside of the nation's laboratories, but the records of physical examinations during the first few months of our "defense" program were convincing.

We established an army of the most physically fit of our young men, and left no stone unturned to assure them the most nutritive and appetizing food, so they would be contented in spirit and in the best physical condition to meet the demands placed upon them by modern warfare. Industrial workers were told repeatedly that they were just as essential in winning the war—every hour and every day from work meant less production, and less production meant less equipment for our combat forces and for our Allies. Yet, there was no comparison between the adequacy of facilities provided for the two. Physically, the war worker may have been a man who had been turned down by the army because of some disability. Too, a large number of them came from our poorest-fed families, which before the war were just existing. Women and older men constituted an ever-growing portion of factory personnel as more men were drafted.

A surprisingly large portion of our population is actually malnourished. Dr. Hazel K. Stiebeling's (75) study of diets of workers' families in the United States showed that 26 per cent of the diets were "poor" and 45 per cent were only "fair." A large part of the malnutrition resulting therefrom is not evident and can only be accurately estimated by the latest diagnostic methods and with special apparatus. Invisible as these deficiencies are, they contribute to poor health and loss of productive ability.

Before the United States entered the war, the improvement of British workers' diets had received attention. In England, in 1940, successful experiments were reported in introducing the "Oslo Meal" in canteens to compete with other foods served. The Oslo Meal consists of 1½ pints of milk, whole grain bread, half an orange, cheese, buttered rusks, half an apple or a carrot, and a tablespoonful of cod liver oil, and for years had been fed to children in some of the

Scandinavian schools. Later, the British Minister of Labour ordered establishment of canteen service in every factory using 250 or more employees. Sir John Boyd Orr (114) stated in 1941:

> The primary effects of malnutrition as seen in the deficiency diseases are well known. Only one—the effect on working efficiency, which is of special importance at the present time—needs to be referred to here. The improvement of the diet of workmen whose diet was not previously up to the standard for health is followed by increased output without any conscious increased effort and also by a reduction in the number of accidents. Many factories are now providing a meal for employes. It is likely that, as part of the national effort for increased output of war material, the provision of a meal will be made compulsory in all factories and measures be taken to insure that the meal is on the lines of the Oslo breakfast, which will make good the deficiencies of the portion of the diet eaten at home.

The Royal Air Force, alarmed by the large percentage of recruits turned down for service for physical reasons, set up a depot for would-be recruits, fed them an optimum diet, and saw that they had sufficient hard physical work, had healthy recreation, and long, sound sleep. Milk and fruit were added to the presumably adequate army ration. In addition to the four regular meals, the men were served a snack at 10:30 a.m. (milk or soup or fruit) and tea (tea, biscuits and barley sugar) in the afternoon. Of the 834 men so treated, 87 per cent subsequently passed the physical examination for enlistment in the R.A.F.

England's "British Restaurants" should be mentioned. The English have long been aware of the problems created by the housewife working in a factory. To help insure everyone obtaining sufficient amounts of good food, that country established a number of local restaurants. These were located not only in factory neighborhoods, but also in residence areas. At these restaurants one might obtain meals at cost. The Ministry of Food financed the construction of these British Restaurants, covers operating losses, if any, and provides trained people to give advice. In 1941 all catering establishments were placed in three classes. Class A covered

approved caterers serving workers in heavy industries of national importance; Class B covered all other industrial canteens and private establishments wholly or mainly serving industrial workers. All other caterers fell into Class C. Class C received the ordinary food allowances; classes A and B received extra allowances.

The United States had no body with such regulatory powers as has the British Ministry of Food. Our only comparable government agency was the War Food Administration, which had a division on industrial nutrition. This division was established in April, 1943, but had functioned previous to that time under the Nutrition Section of the Office of Defense, Health and Welfare Services. The division's eleven regional offices throughout the country, worked closely with local nutrition groups, giving them advice, educational material, and in turn, reporting local conditions to the War Food Administration. Work was coordinated with that of the Department of Agriculture, the Office of Price Administration, and the War Production Board, through a coordinating committee.

The Food and Nutrition Board of the National Research Council, recognizing that industrial nutrition was a subject which demanded immediate attention, in 1941, established a Committee on Nutrition in Industry, later called the "Committee on the Nutrition of Industrial Workers." The purpose of this committee was to determine the adequacy of meals as chosen by workers, the actual physical health of workers, the adequacy of already existing eating facilities, the desirability of special rations for special types of work, the loss of vitamins in preparation of food, and to act in general as advisor to government departments dealing with industrial problems. The recommendations of this committee were given at the National Nutrition Conference for Defense, called by the President in 1941.

Do workers carry lunch pails by preference, or is it because they have no choice? Do they choose "good" diets when they have the opportunity to do so? To obtain information

on these questions, the Committee on the Nutrition of Industrial Workers asked Dr. Robert S. Goodhart, vice-chairman of the committee, to visit 33 industrial plants in different parts of the country. In the summer of 1941 Dr. Goodhart found that 27 of the industries were interested in adequate nutrition for their workers, but almost all stated that they did not have trained personnel to cope with the problem. He observed the lunches chosen by workers, and found that even where good food was available, a majority of the workers chose poor meals. Only 10 to 25 per cent chose milk. Large numbers did not eat breakfast, yet drove as far as forty miles to work. One plant's lunch concession served these men coffee and doughnuts every morning. Similarly, in a plant on the east coast, it had become the custom to eat Danish pastry and coffee at the machines during the morning. He found in a great many plants that sales of "soft drinks" were twice those of milk and orange juice. This survey indicated that a great many industrial workers were not receiving proper food to carry on a hard day's work and maintain good health. These were only observations, though, and there was need of detailed investigation before any recommendations were made.

The Lockheed Experiment

To determine whether improved diet will result in more airplane propellers or tank treads the Food and Nutrition Board (115) planned a controlled survey of four plants in different parts of the country. At the Lockheed plant in California 1,100 employee volunteers cooperated during the period from November, 1941, to February, 1942. The majority of the men were young; three-fourths of them were under thirty. They were also a "healthy" group, since they were hired at a time when it was necessary to pass a thorough physical examination. Almost all the men studied were employed on night or "swing" shifts, since a majority of accidents and much of the absenteeism occurs among night workers. That an adequate selection of foods was available

in that area to meet nutritional requirements had been shown by the studies of Stiebeling and Phipard (116), which indicate that there are fewer "poor" diets among workers' families on the Pacific coast than any other part of the country.

Every attempt was made to record an accurate picture of the nutritional status of these workers. First, a record was made of the types of food eaten by each man, both at home and in the factory, over a period of seven days. An analysis of these records revealed that only two per cent of the men reported diets which met the recommended allowances; eleven per cent reported marginal diets, and 87 per cent reported diets which were unsatisfactory in one or more types of food. Most of the workers obtained sufficient protein, but over half did not eat adequate amounts of green and yellow vegetables, and only 36 per cent had one or more servings of citrus fruit and tomatoes a day—the chief sources of vitamin C. This latter observation is an interesting one for California is one of our largest citrus fruit producers. Further, analysis disclosed that the diets of those who had recently arrived in the state tended to contain more citrus fruits than those of families who had lived in the state for some time. One-third of the group failed to get enough milk and milk products, and a fifth of the diets were low in eggs.

From medical examinations, using all the latest methods of detecting deficiencies of vitamin A, thiamin, riboflavin, niacin, and ascorbic acid, almost all the men showed vitamin A deficiency, either past or present. From 17 to 26 per cent showed thiamin deficiency of varying degrees. The low citrus fruit consumption was reflected in the results for ascorbic acid in the blood, which showed over half the men were eating less than the amount required for good health. Forty per cent of the subjects complained of gastrointestinal disturbances; sixty-three per cent reported that they had had one or more colds during the preceding three months. Twelve per cent of the men said that they found their work excessively "tiring."

The study revealed no cases of gross deficiency disease, but reemphasized the marginal nature of most American diets, even in regions where a selection of food is available and people have adequate incomes. With many of these men, the addition of one or two foods to the diet would change them from inadequate to adequate. The high number of gastrointestinal disturbances reported is a real challenge—for almost all the men who participated in the study were young, and supposedly healthy individuals. Forty per cent is a very high incidence in such a group.

Industrial Use of Commercial Vitamin Products

In addition to the investigation into adequacy of diet, synthetic vitamins were fed to the men of the Lockheed study in an effort to observe any effect on performance, especially with those men with histories of deficiency. This phase of the study, carried on for one year, indicated that performance was definitely influenced by the administration of the additional vitamins. Since that time, other plants in the same vicinity have tried administering vitamins in a fruit beverage and in a "vitamized" cookie during a ten-minute rest period. It is anticipated that the results of this method of administering the vitamins will be even more outstanding, in terms of performance, when they are compiled.

Vitamin pills or capsules to step up production have enormous appeal to a great many employes, and employers too. They are regarded as a magic formula—something like Aladdin's lamp or Popeye's can of spinach—which will enable the person to accomplish anything he wishes. Workers at some factories find vitamin pills for sale at the lunch rooms. Other employers contribute them, hoping to increase production. Most of the plants which are advocating vitamin pills or capsules have not investigated methods of supplying these vitamins to their workers in natural foods. In a few instances it may not be possible to provide proper foods for employes, or to influence by other means the adequacy of their diets. In these instances, it is possible

that vitamin concentrates, or even synthetic vitamins, might serve a purpose. The difficulty is that vitamins do not constitute all of the dietary requirements of human beings, and the vitamins which can at present be given in synthetic form are not all the vitamins required by the body. Furthermore, where synthetic vitamins have been administered in industries, usually no attempt has been made to determine what vitamins are lacking in each worker's diet. Indiscriminate dosage of synthetic vitamins is rather like aiming a machine gun in the dark—you hope if you cover enough territory you will hit your target. In fact, the practice has been called "shotgun" administration.

Vitamins, particularly vitamin C and those of the B complex, are playing an important part in protection against industrial toxicosis, a serious problem in plants using chemicals. Animal experiments indicate that adequate nutrition is necessary for protection against early effects of toxic chemicals. During the war, because too precious time would be expended in educating these workers to eat foods which would protect them against these hazards, synthetic vitamins were administered. There is no evidence that workers exposed to trinitrotoluene (TNT) and other toxic chemicals require for their protection a daily consumption of milk and perhaps a supply of vitamin C greater than that which can reasonably be supplied by a careful choice of foods available today.

The War Worker Still Needs Calories

Calories have become "old-fashioned" since the glamorous vitamins have taken the spotlight. It is equally important, however, that workers obtain sufficient calories from their meals. The calorie requirement per worker varies with age, sex and type of work. In the Lockheed survey, a considerable number of the men were not receiving enough calories to carry them through a daily eight hours of work plus their other activities. This may, in part, account for the feeling of tiredness reported by some of the workers.

Although vitamins do aid in better utilization of calories, vitamin capsules will not substitute for an inadequate caloric intake.

In England, during the war, it was suggested that working people be given additional ration points in proportion to the energy they expended. The decision was that it would be impossible to catalogue all the various types of work, and that such a system would be entirely impractical. Certain foods, though, were made available in additional amounts to factory canteens. In the United States, lumbermen of the logging industry in the Northwest were studied to determine their calorie needs. These men, who are very active and do very strenuous work, were found to have an average requirement of 6000 calories per day, in contrast with the aircraft workers in California whose average intake of calories was about 3000. Studies such as these furnish information upon which to base food allowances in factory cafeterias and restaurants.

Women in Industry

Adequate nutrition for women is another special problem in industry today, with the employment of more and more women in factories. There is more absenteeism among women workers than among men. Some women have acquired "bird-like" appetites from poor eating habits and may not eat enough food to supply their energy requirement while doing factory work and thus may be more prone to disease. Many other women do not realize the importance of enough food of the proper kinds in the maintenance of their health. The woman with a factory job must realize that she is doing a man's job and must eat a man-sized meal. Many women dread "getting fat." Women factory workers who restrict their food consumption to the amount they ate when they were staying at home do not stop to think that the additional amount of food they desire will not "go into fat," but will be burned by the body to produce the additional amount of energy needed, and that if this additional

food is not furnished, the body's tissues themselves will be consumed to furnish the energy.

The majority of women who took industrial war jobs were motivated by patriotic and financial reasons, although a few used the war as an opportunity to escape from unsatisfactory home environments. Thousands of women returned to their professions, to office work or volunteered to work in war plants solely because they were needed and could in these ways serve their country best. These women frequently made personal sacrifices to help war production and release men of fighting age. The women who took war jobs for financial reasons can be divided into two general groups—those who sought employment because it became imperative that they earn money with which to maintain their homes and those who wished to increase their income to provide for a higher standard of living, luxuries, financial independence, or increased savings.

The vast majority of these women made real contributions to the successful prosecution of the war and to our postwar economy. A small number were misled by patriotic motives and attempted to fulfill the stringent demands of a war job in addition to continuing already strenuous obligations in their homes. Others made the same attempt for the "extra" money and yet another group because they felt it was "necessary." In the majority of instances in which women attempted jobs outside the home which were too much for them, the excessive burden has been attributable to obligations involving dependents. Many of these women were unable to meet the physical demands of this dual responsibility, their health declined, regardless of any effort towards maintaining good nutrition, and their absenteeism made them unsatisfactory as employes.

The industrial nutrition program in its application to the woman worker encompassed various programs designed to ease the burden of the women who must continue to be both homemaker and breadwinner. However, the manpower, or womanpower, reservoir of the nation remained large and

even during the war there was no need for (in fact both military and civilian agencies discouraged) employment of women with young children if any other plan of support was available. For those mothers who thought it was necessary for them to work, a nursery school program was established to assume the responsibility for the safety and nutrition of their children during the working hours. While the nursery school program was the best solution possible for the problems of working mothers, claims that nursery school care can fully substitute for maternal care in the home have not been made.

The preschool nurseries established in industrial areas by various organizations and individuals cared for children from two years of age to school age. The charge per child per day was as low as fifty cents. Some of the nurseries had a sliding scale, adjusted to the income of the child's family; some charged fifty cents a day, including the noon meal, and additional if the child ate breakfast at the nursery. Some of the nurseries were privately operated, others were operated by local government or social service agencies. The entire program was aided by subsidies from the federal government.

While nurseries solved many problems for women war workers, they were not just a wartime measure; preschool nurseries existed long before the war and the experience of already-existing nurseries was used in setting up the wartime nurseries. One of the oldest and best established nursery schools in the United States operates, in part, as a training center for nursery school teachers and as a proving ground for nursery school procedures. The Merrill-Palmer School, Detroit, is unique in its objectives. The will of Lizzie Merrill Palmer stated:

> I hold profoundly the conviction that the welfare of any community is divinely, and hence inseparably, dependent upon the quality of its motherhood, and the spirit and character of its homes, and, moved by this conviction, I hereby give all the rest of my estate for the founding, endowment and maintenance, in the City of Detroit, of a school at which

girls and young women shall be educated, trained, developed and disciplined with special reference to fitting them mentally, morally, physically and religiously for the functions and service of wifehood and motherhood, and the management, supervision, direction and inspiration of homes.

At a nursery a child receives at least one good, well balanced meal each day. Trained personnel assure his eating the meal and taking a nap and they supervise his play. He is in competent hands, and the mother may go to her work relatively free from worry. Also, the nursery provides a training ground for the development of good food and social habits. There is a definite need at all times for such a service, for mothers who must work, at a cost which they can afford to pay.

Requirements for Adequate Industrial Nutrition

Providing well-planned meals in an industrial organization calls for a combination of nutrition knowledge, managerial ability and salesmanship. These attributes may be combined in one person or several, although it is desirable that the medical department and the cafeteria work in close cooperation so that they may supplement each other. It is a fact that, faced with a wide selection of food, workers five times out of ten will choose a poorly balanced meal. It is the task of the cafeteria management not only to provide the proper food, but to try to influence the choice of the workers so that they will obtain *at least a third of the day's requirements* at each meal eaten at the plant. Very few of the breakfasts eaten by workers contain a third of the day's required nutriments, so it is doubly important that the meal at the factory furnish at least a third.

Enterprising dietitians in some plants have devised their own educational methods of influencing the worker's diet. Some have featured a special lunch, well-planned meals, meeting all nutritional requirements, attractively arranged on a tray, with emphasis on color and arrangement, and displayed at the beginning of the cafeteria line along with a statement that this lunch was chosen from the 7 Basic Foods.

A surprisingly large number of workers choose this lunch in preference to their usual fare. Another method employed with success is reducing the price of highly nutritious foods so that it is cheaper to buy an attractive, nutritious sandwich than a cup of coffee and doughnuts. In one large war plant the price of coffee was five cents and milk seven cents. The prices were reversed and sales paralleled the prices. Habits formed from eating at the factory cafeteria are often carried home and have a decided influence on the preparation of the family's meals.

Preparing and cooking cafeteria food so that it will retain most of its nourishing qualities requires personnel trained in the latest methods of large-scale cooking. Peeling, excessive cooking and standing after cooking each reduce the nutritive value of the food so that only a fraction of the amounts of vitamins and minerals may remain. The cafeteria manager, therefore, must organize his kitchen routine so that a minimum of time elapses between preparation and consumption and prepare the food so that a minimum of its nutritive values are destroyed.

Other educational activities include nutrition displays, especially where people have to stand in line, and nutrition literature passed out to workers. Some union organizations have even conducted nutrition classes for women in the factory and non-working wives of male employes. Much can and should be done in educating the man who will always carry his lunch. Now that enriched bread is available, all sandwiches should be made from whole grain bread or enriched bread. Lunch hours should be long enough to enable a worker to eat a nutritious meal. There are companies which only allow employes fifteen minutes to get their lunches, eat them, and get back to work. When the gong for the lunch period rings in these plants, a man could be trampled in the rush. There is barely time enough to swallow the food, let alone relax for five minutes. Many workers will not carry an orange in their lunches because they "haven't time to peel it."

Between-meal snacks are receiving a good deal of attention at the present time. There are very few factories which provide for mid-shift feeding, but there are hundreds that have soft drink and candy-vending machines or carts, which thousands of employes patronize every day. The practice of between meal snacks of nutritious foods for factory workers is approved by nutrition authorities. The effects of a ten-minute relaxation period and some food would pay dividends in production. Hundreds of employes stop work every day to get a candy bar or a soft drink. If cold milk, tomato juice, orange juice, wholesome cookies and other good foods were available at the same cost, and could be eaten during a rest period, the sale of candy and bottled drinks would drop off and the workers would be in much better health. An interesting incident occurred in Canadian factories when the government placed a tax of one cent on bottled soft drinks to obtain additional revenue. Workers had to have the correct change or wait for change, and the result was that the sale of milk, which remained at five cents, increased considerably.

Particularly serious has been the problem of absenteeism on the night shift and among women workers. Probably the most common excuse is "I don't feel like going to work today." There may be nothing specifically wrong with the person, but he has been working nine hours a day, or seven days a week, and one morning he just feels too weary to get out of bed. There are, in addition, a great many days lost because of illness—colds, influenza, and grippe accounting for a large part of them. The number of days lost from both the latter causes is greater for older employes and greater for women than for men.

William H. Gafafer (117) in 1943 reported that the annual number of absences of eight days or more per 1,000 male employes was 116.7 for men under 50, and 166.9 for men over 50. He gave an annual rate of 91.1 for 1,000 men as compared to 148.1 for the same number of women. To what extent "tiredness" and illness are attributable to poor nutrition is

difficult to determine. There are other factors to consider; the worker must not be attempting more than he or she is physically able to accomplish, and he must get sufficient rest. Excessive drinking can destroy the best laid plans for an adequate diet for it has been shown that alcohol greatly increases the body requirement for thiamin and vitamin C. whole wh

Holmes, Pigott, Sawyer and Comstock (118), realizing that respiratory diseases account for at least half of employes' absences, conducted a five-year experiment to determine whether additional amounts of vitamin A in the form of cod liver oil would reduce the number of days lost on account of these diseases. The experiment was very carefully planned, using a "control group"—employes who did not receive the cod liver oil—for comparison. The results showed that those receiving the cod liver oil were absent materially less time than the control group. Also, those receiving the cod liver oil found that they had fewer colds each year as the study progressed. Employers have worked overtime trying to devise ways of combating absenteeism, but few have tackled the problem from the angle of preventing illness by adequate nutrition, although it is generally agreed that resistance to disease is dependent upon the body's nutritional state.

The worker who is tired may convince himself that he cannot afford to be docked for the day, and force himself to get up and go to work. Perhaps his mind acts very slowly, or his attention wanders from the task he is doing, or perhaps his fingers aren't as agile as usual—a hand slips and his fingers are lacerated. This sort of thing happens many times a day in factories. There is no doubt that gross deficiency diseases, such as beriberi and scurvy, will reduce alertness and accuracy, and there is evidence also that the less obvious, chronic deficiencies of all types may undermine efficiency.

Experiments have been conducted in which rats were fed diets adequate in everything except thiamin. After the rats had been on the thiamin-deficient diet for some time the investigators found that their movements became clumsy and awkward. In this experiment the diet was deficient

only in thiamin; human beings usually have deficiencies of several vitamins if they have a deficiency of one, and occupational accidents might be materially reduced if all workers ate food that would maintain buoyant health and alertness.

The worker on the night shift requires special attention. Starting this shift he suddenly finds his world turned topsy-turvy. He comes home as others are leaving for work. His meals are confused—he does not know whether to eat breakfast after coming from work, or eat it at night before leaving home. The rest of the family and community are up and the worker may delay going to bed. When he does go to bed, he often sleeps lightly owing to the noise of daily activities. He gets up too late for lunch and too early for the family dinner hour, creating a choice between eating a snack and spoiling his dinner, or just waiting until dinner time. He leaves for work just as others are going to bed. A person starting on this shift has a serious adjustment to make and it is very important that he have the proper food and sufficient rest. The large number of accidents and absences which occur among night shift workers emphasize the importance of special attention to keep them physically fit.

In addition to the increased physical demands placed upon industrial workers there are also psychological factors which affect health and efficiency. Prominent among these factors is worry. Disturbed mental states are not conducive to efficient work, and also have detrimental effects on digestive processes, so that a person does not derive the full benefit of the food he consumes.

Every person should be interested in maintaining the best possible health, and probably is, but perhaps he doesn't know what foods he should eat; perhaps the types of food he should have are not available in his neighborhood, or he hasn't time to shop for them. The government is vitally interested in the health of the people, but we live in a democracy and desirable as it may be that everyone include all the essential nutriments in his meals every day, govern-

ment agencies can serve only as advisors and consultants. Each State was asked at the beginning of the war to establish a nutrition committee. Some of these appointed subcommittees on industrial nutrition, which worked closely with local plants. The committees included representatives of health departments, the industrial hygiene division, industrial organizations, physicians, labor representatives, food producers and merchants, caterers, service clubs, and newspapermen, as well as nutritionists.

Organized labor is in an admirable position to improve the health of its members. Some of the labor groups are actively participating in nutrition endeavors, through exhibits at their meetings, feature articles in their papers and surveys of the adequacy of feeding facilities. A National Labor Advisory Committee represents unions within the Congress of Industrial Organizations, the American Federation of Labor, their respective auxiliaries, and the Railway Brotherhoods. The Industrial Nutrition Division of the Food Administration is in constant touch with these representatives. Both have asked state and city organizations to cooperate with the local nutrition committee. Each labor group is urged to set up its own nutrition committee, the chairman to function as a delegate to the local nutrition committee.

The fundamental reason for organizing labor has been to unite workers so that they may present a united front in their requests for a "square deal." The whole problem of industrial feeding should, therefore, be a real challenge to the union organizations. The "square meal" should be an integral part of the "square deal." It is difficult to think of any other measure which would do more for the health and well being of its members than a program to insure adequate nutrition for industrial workers. Union groups could even operate lunchrooms, on a non-profit, no-loss basis. There is not a reason why a factory worker must sit on a stool in a dingy, smoky shack to consume a fried hamburger and a piece of leathery pie; why factory employes

cannot eat in a light, cheerful cafeteria where they may purchase at cost, a colorful, tasty and nutritious meal, which would eliminate many complaints of indigestion. Many factories would cooperate by contributing space, heat and light for such cafeterias.

Actually, the employer has as much to gain as anyone else from adequate feeding of his employes. Some of the large plants constructed during the past few years contain cafeterias in sufficient numbers and capacity to feed all the employes. In May, 1943, it was estimated that 20 per cent of all workers were being fed at least one meal a day through inplant feeding. More than 90 per cent of the factories had lunch periods of 30 minutes or longer; a very few had no lunch periods whatsoever. The types of food service available in American factories include: central cafeterias or lunchrooms; trucks which transport the food from the central commissary to different parts of the plant; a combination service where those adjacent to the cafeteria are fed there and those in other parts of the plant are fed by canteens; and box lunches distributed through the plant by the plant commissary or by a commercial food purveyor. The plant may own and operate these facilities, or they may be employe-managed, or an outside commercial commissary may own and operate them or rent space from the plant.

Although there is a good deal more interest in health and nutrition than ever before, the employer must still be shown that he will receive some return on his investment—not in profit from cafeterias or canteens, but in increased production, and a decrease in industrial accidents and absenteeism. Consumer's Guide (119) described the experience of one small manufacturer, as a result of the national nutrition campaign:

> William L. Belknap, president of an old New England company that manufactured bayonets during the Civil War, installed a cafeteria in his ivy-covered plant, where today valves for war machinery are turned out. He hired an excellent Swiss chef, who serves 3,100 meals a month at 35 cents each. They cost the company sixty-two and a half cents per meal

for food and labor, but the company finds that they pay dividends in increased production. Most of the men used to bring lunches from home. They started eating at their benches about 9:30 in the morning, finishing the last piece of fruit around the middle of the afternoon. All this nibbling slowed production. Now 99 per cent of the workers eat in the cafeteria, where an average meal consists of roast beef and gravy, mashed potatoes, harvard beets, corn and string beans, lettuce and tomato salad, bread, pie, or cake, milk or coffee.

Adequate eating facilities are not the whole answer to the problem. Nothing has been gained if a plant opens a spacious cafeteria and serves only hamburgers, pie, cake and coffee. In cafeterias and lunchrooms workers should be able to obtain a nutritious meal; and planning nutritious meals requires trained personnel. Dr. Goodhart found, in his survey of 33 large plants in 1941, that only two of them employed nutrition experts. A large number of plants are served by big concessionaires which operate in a chain of plants; many of these companies do not have a dietitian on the staff. The chief purpose of these organizations, of course, is to make a profit, because serving meals is their business. Plant-operated lunchrooms and cafeterias, on the other hand, usually operate on a cost basis, and often at a loss. Not enough publicity has been given to this situation, which may account for the fact that plant-operated lunchrooms are not always well patronized. Many workers may feel that the plant is trying to make a profit from serving them meals, while in reality the plant may be providing the service as a convenience and sometimes at considerable expense.

There are a few instances, though, in which the plant puts the lunchrooms in charge of an "efficiency expert" whose concern is not what foods the workers are served, but how cheaply they can be served. Also, in a few plants, a dietitian is on the staff of the lunchroom but she is not in charge, and is serving only in an advisory capacity. It has also been the practice in a small number of factories to give the medical department some responsibility in the management of lunchrooms. Usually, though, the medical department is not directly responsible for the operation of the lunchroom, and

the physician's chief duty usually is to check on sanitary conditions. It is a curious fact that while we would not turn to a trained automobile mechanic about the function of such a delicate mechanism as the human stomach, yet we are content to put anyone in charge of our meal planning so long as we get what we like and we don't have to pay too much for it.

Chapter Ten

FOOD TO FIGHT

Before World War I, investigators in the United States Public Health Service had demonstrated that certain diseases such as pellagra might result from faulty diet, but as long as people were not starving from lack of food and manpower requirements were not critical there was lack of interest on the part of authorities as to whether they were getting the right kind of food. When the armed forces were given the job of winning a war, they were interested in turning out the best-fighting soldiers possible. They explored all sources of aid in this direction and did not hesitate to seek and to put into practice the advice of food and nutrition authorities. The recognition by the U.S. Army of the progress in nutrition is illustrated best in the words of Capt. R. J. Anderson (120), Section of Food and Nutrition, Division of Sanitation, Medical Department, U.S. Army, who in 1919 reported on "The Practicability of Feeding a Scientifically Balanced Ration in Army Camps."

> The proper feeding of an army or army divisions . . . presents several important problems. First of all available food supplies must be considered. . . . Equally important are the matters of storage, the prevention of spoilage and the cooking of the raw food products into edible and nutritious food. With ample food supplies available, those responsible for the feeding of the army must select such combinations of food as will safeguard and maintain the health of the troops and increase their vigor. In this selection it is necessary to consider the relative proportions of protein, fat and carbohydrate, and perhaps also the acid and base elements contained in the food, together with so-called vitamines, which should be supplied for a properly balanced diet. In addition to the above a satisfactory diet must also contain a certain amount of roughage or indigestible residue.

With slight modification this statement would serve as a guide at the present time. At that time variety and fresh-

ness of foods were emphasized to assure the unknown vitamins. Today, the emphasis is placed on securing the proper quality and amount of protein, and the necessary amounts of vitamins and minerals. Variety is less important for good nutrition of troops than for satisfying their palates.

Nutrition Knowledge from World War I

In an address to the National Nutrition Conference, in 1941, Professor John R. Murlin (17) of the University of Rochester and during World War I the principal army advisor on nutrition stated: "In contrast with the interests as they were thus outlined for the Army in 1917, there was going on at the same time, in relation to the general population, an intensive drive for the incorporation of larger amounts of milk and other dairy products in the diet to see that there was an adequacy of this new factor called fat-soluble A as well as more calcium and phosphorus. That was one of the chief points emphasized. The Army was afraid of milk for fear the drinking of milk might develop milksop soldiers. They did not want soldiers to drink milk!"

The actual food requirement of the soldier was one of the main interests of the Food and Nutrition Division during World War I. Under the leadership of various officers, nutritional surveys, beginning October 1, 1917, and continuing until December 1, 1918, were made in sixty-seven different camps, including forty-nine divisional and other large concentration camps, fourteen aviation fields, three war prison barracks, one recruiting station and one spruce production camp (121). Twenty-six of these camps were surveyed a second time and three of them a third time. The results of these surveys on a total of 427 individual messes were reported (Table 16) in 1919 by Murlin and Hildebrandt.

In World War I the average weight of the soldier after four to five months of training was 146 pounds. Using the above figure for average food consumption, the soldiers consumed 24.6 calories per pound of body weight or 52.1 calories per kilogram. The range in food consumption by the

427 messes studied varied from 2100 to 5700 calories per man per day. Certain factors such as (a) the effect of season; (b) effect of the length of time in camp; and (c) the effect of canteen purchases, which are not brought out in average figures but were important in evaluating the dietaries, were emphasized in this report.

With regard to the effect of season, it was found that there was a gradual increase in food consumption from November to March, after which there was a sharp decline which continued throughout the summer. The average soldier daily consumed 300 to 400 calories more throughout the winter months than in the summer months. Recruits lost weight during the first week in camp but the loss was recovered by the end of the third week. A study of the food consumption in recruit organizations showed 2700 calories per man per day in the first week, increasing to 3000 in the second, 3100 in the third week and 3600 calories the fifth week. The effect of canteen purchases was insignificant. In 261 studies at canteens or post exchanges the average food consumption per man per day was found to be 365 calories. Thus, the estimate from studies of both messes and canteens was that the soldier consumed an average of 4000 calories per day.

TABLE 16

Average Food Consumption in the Training Camps of the United States Army (1917–1918)

Average of 427 messes

Nutrients	Food per man per day			Distribution of food value		
	Supplied	Wasted	Consumed	Consumed, per cent	Wasted, per cent	Per man per day
Protein, gm........	131	9	122	14	7	Supplied cost—44.06 cents
Fat, gm............	134	11	123	31	8	Waste cost—3.20 cents
Carbohydrate, gm..	516	31	485	55	6	Total waste—0.80 pounds
Fuel value—calories.	3899	266	3633	100	7	Edible waste—0.38 pounds

The authors made an interesting demonstration of how the actual average food consumption of the World War I

soldier satisfied his theoretical energy needs. Using the average weight of 146 pounds and the values for energy expenditure calculated by Lusk, the soldier's calorie intake would be distributed as follows: basal metabolism, 1695; standing, 113; walking 30 miles in 10 hours, 1606; carrying 44 pounds of equipment, 484 calories. Thus, the total requirement of the average soldier would be 3898 calories every 24 hours to do his maximum work. If the maximum work was not done and he continued to consume 4000 calories he would gain weight. Murlin and Hildebrandt point out that recruits gained anywhere from 3 to 9 pounds in the course of the 4 to 5 months training period.

Comparison of the American soldier's training ration with those of other allied armies (Table 17) shows that the American soldier had a diet much higher in energy value, although the percentage of protein in the United States Army ration was lower than that of the British, Canadian, French or Italian armies. The percentage of fat was lower than the amount prescribed for the British and Canadian Armies and higher than that of the French and Italian armies.

During World War I the average soldier received more than a sufficient supply of calories to meet his daily energy expenditures; the relative distribution of these calories among protein, fat and carbohydrate being 13, 31 and 56 per cent respectively. As might be expected, the most important foods from the quantitative standpoint were bread, meat, potatoes and sugar. In addition, there were dried beans, canned peas and corn, evaporated milk, cheese, eggs, butter, prunes, and dried peaches and a long list of cereal products such as hominy, corn meal, breakfast foods, oatmeal, rice and macaroni. Lard, flour and oleomargarine were used extensively and the meats were diversified, including pork, sausage, bacon, ham, both canned and fresh beef, and veal, as well as liver, fish and poultry.

In the light of the great strides the science of nutrition has made since the foregoing dietary was used, one is impressed by the absence of fresh fruits, vegetables and milk. The

TABLE 17

TRAINING RATIONS OF THE DIFFERENT ALLIED ARMIES (121)

	Protein, gm.	Fat, gm.	Carbohydrates, gm.	Total calories	Protein	Fat	Carbohydrates
					Percentages of calories		
British home ration, May, 1918	124	136	419	3483	14.6	36.4	49.0
Canadian, July, 1918	107	118	344	2946	14.9	37.2	47.9
French, normal, March 29, 1918	138	98	467	3604	15.7	25.3	59.0
Italian territorial, February 1, 1917	127	38	469	2797	18.6	12.6	68.8
United States Garrison ration A.R. 1221	147	174	643	4859	12.5	33.3	54.2
Consumed in United States training camps 427 messes and canteens purchases	129	136	545	3998	13.0	31.0	56.0

overabundance of cereal and starchy foods, as well as the great emphasis placed on meat, reflect the energy and satiety concepts of nutrition at that time. The really important fact, however, should not be lost sight of: our army was still the best fed of all the fighting forces and it was fed according to the best nutrition concepts of the time.

Garrison Rations—World War II

The basic garrison ration for our troops was designated Field Ration A and included perishable and non-perishable foods that most of us are accustomed to eating. Officially, a ration is the food for one man for one day. Each service command in the country received an advance, suggestive master menu from the Quartermaster General at monthly intervals. In practice these menus were followed rather closely because they were based on expert knowledge of which foods would be available in various producing areas and were checked for nutritional quality by specialists. Staff officers are responsible for the nutrition of the men under their command, therefore, the commanding officer of the service command, or of a post, had the privilege of making whatever adjustments local conditions required. The menus on which the food finally was issued were sent to the Office

of the Quartermaster General for a final check of nutritional quality. The fact that the average soldier gained about eight pounds during his first two months of service is proof that Field Ration A was nutritious and well-balanced.

The troops overseas got Field Ration A, so far as it was possible. When supplies of fresh fruits, vegetables and meat were not available but divisions were still eating as units, the soldiers received the same type of foods as in Field Ration A but all food was canned or preserved (Field Ration B). Because of the restricted variety of processed foods, and to simplify the problems of procurement, transportation, storage and issue, the nutritionists in the Office of the Quartermaster General planned the menus to repeat themselves every ten days, also avoiding association of any menu with a day of the week. A glimpse at the garrison ration of World War II in contrast to the rations of previous wars (Table 18) makes us realize how far the master menus succeeded.

The adequacy of the dietary in World War I was judged by its amounts of energy, protein, fat, carbohydrate, ash and bulk and the importance only of vitamin C and calcium were appreciated. In addition to energy, protein, fat and carbohydrate, the 1944 soldier received known amounts of numerous vitamins and minerals, including the essential trace elements, copper, iron, manganese and zinc. The approximate nutritive value of foods supplied the army in 1918 and in 1941 are not conspicuously different (Table 19), according to values given by Howe (122).

Combat Rations—World War II

The armed forces had the guidance of the Food and Nutrition Board of the National Research Council in setting up the allowances of food for servicemen. The establishment of the "yardstick" presented to the armed forces and the public the problem of attaining these allowances. The recommended allowances provoked general interest in the nutritive value of foods, in the variations to be expected in the same food, and the extent to which the biological value of proteins and

TABLE 18

VARIETY AND AMOUNTS OI FOODS FURNISHED EACH SOLDIER BY U. S. ARMY RATIONS (Ounces per day)

Food	World War II 1941	World War I 1917	Spanish-American 1898	Civil 1860	Mexican 1838	War of 1812	Revolutionary
Milk							
Fresh	8	.....	......	.....	.....	.....	16
Evaporated	1	0.5					
Vegetables							
Beans							
String	3						
Dry	0.5	2.4	2.4	2.6	2.4		
Corn	2						
Onions	2						
Peas	2	.....	......	.....	.....	.....	6.9
Potatoes	10	20	16				
Fruits							
Apples	1.5						
Peaches	1.2						
Pineapple	1.2						
Prunes	0.3	1.28					
Tomato	2						
Eggs (number of whole)	1						
Meat, cheese, fish, fowl							
Cheese	0.25						
Bacon	2						
Beef	10	20	20	20	20	20	16
Chicken	2						
Pork	4						
Cereals and bread							
Flour	12	18	18	18	18	18	16
Macaroni	0.25						
Rice	0.6	.....	......	.....	.....	.....	1.1
Rolled oats	1.5						
Fats							
Butter	2	0.5					
Lard	0.64	0.64					
Others	0.64						
Salt	0.5	0.64	0.64	0.64	0.64	0.64	
Yeast powder	.....	.....	......	0.04			
Sugar							
Candy	0.8						
Jams or preserves	0.5						
Sugar	5	3.2	2.4	2.4	1.92		
Syrup	0.5	0.32					
Beverages							
Beer	.....	.....	......	.....	.....	.....	32
Cocoa	0.3						
Coffee	2	1.1	1.6	1.6	0.96		
Rum	.....	.....	......	.....	.....	4	
Tea	0.05						
Condiments							
Baking powder	0.09	0.08	0.64				
Cinnamon	0.014	0.014					
Flavoring extract	0.02	0.014					
Pepper (black)	0.04	0.04	0.04	0.04			
Pickles	0.16						
Vinegar	0.16	0.64	1.28	1.28	0.64	4	

some of the less stable nutriments, such as carotene, vitamin A, thiamin, riboflavin, niacin and ascorbic acid are retained or destroyed during harvesting, processing, storage and preparation of food for eating. Contrasted with the emphasis in World War I on the wide selection of foods to provide a balanced diet is the statement of Colonel Howe (123) who headed the Food and Nutrition Subdivision of the Professional

TABLE 19

Approximate Nutritive Value of Foods Supplied or Used in the Army in 1918 and 1941

	Nutritive value of food 1941–1942		Nutritive value of food 1918		Daily allowance of specific nutriments recommended by Food and Nutrition Board, N.R.C. for average man weighing 154 lbs.	
	Issued	Consumed	Issued	Consumed	Moderately active	Very active
Energy, calories	4,101	3,888	3,720	3,670	3,000	4,500
Protein, gm	130	124	133	135	70	70
Fat, gm	193	193	127	130		
Carbohydrate, gm	460	415	509	488		
Calcium, mg	954	883	0.68	1.05	800	800
Phosphorus, mg	1,946	1,882	1.93	2.08		
Iron, mg	25	28	0.023	0.022	12	12
Vitamin A, I.U	10,760	9,255	10,480	8,600	5,000	5,000
Thiamin, mg	2.2	2.1	2.79	2.64	1.8	2.3
Riboflavin, mg	3.0	2.3	2.75	3.24	2.7	3.3
Nicotinic acid, mg	32.0	27.4	.....	....	18.0	23.0
Ascorbic acid, mg	93.2	86.0	87	82	75.0	75.0

Service Division, Surgeon General's Office, that it will no longer suffice to assume the dietary is adequate because a wide variety of foods has been provided. The quality and quantities of the various foods eaten become a part of the evaluation. The consumption of sufficient quantities of a few well selected and prepared foods may provide a dietary as adequate as that obtained from a wide variety of foods consumed in small quantities. In fact, many of us live on a relatively restricted dietary.

When fresh foods and vegetables are readily obtainable, there is usually no problem in providing a balanced diet, but in preparing rations without fresh foods it is necessary to calculate the value of each item used. Like other human beings, the soldier is not interested in food for its nutritive value alone. He wants a variety of food which tastes good and stimulates his appetite. It is difficult to grasp the full significance of filling a supply pipeline which extends from factories in the United States to front lines in the temperate zone, the steaming jungle, the dry, burning desert, the frigid wastes of the Arctic and the rarefied atmosphere of mountainous regions; a pipeline which may require a year's supply to fill, before the flow of food at the front is stabilized. Persistent care was used to prepare only foods of high keeping quality. All were tested for storage life under the most adverse climatic conditions. Few foods, if any, will remain completely stable at temperatures of 130°F. or above; some foods are affected by freezing. Some information had been accumulated from special expeditions but never had there been such a unified effort by scientists, industrial and military experts. The Subsistence Research Laboratory, in Chicago, served as the liaison among the Army, the universities and the food industries.

A number of rations were developed for use under special conditions, where perishable foods cannot be obtained and where time and equipment for cooking meals are not available. These include a canned ration "C" carried by the individual as a reserve, and a boxed ration "K," originally developed for parachute troops. The canned ration was used extensively in every theatre of operation; the boxed ration was used widely in combat areas where it was not possible to cook and feed large quantities of food. Field Ration "D" is highly concentrated emergency food, consisting of 3 four-ounce bars of stabilized chocolate wrapped in cellophane and overwrapped in a wax-dipped carton. It is intended for use only when all other forms of food are unavailable. The bars are made of chocolate, sugar, oat flour, cocoa

fat, skim milk powder, artificial flavoring and are fortified with thiamin. The forces landing on Attu carried with them K and D rations and the first food shipment to reach the troops was the C ration.

The C Ration consists of three cans of meat components and three cans of "B Unit" issued to the individual soldier for a one-day supply. The B Unit cans contain biscuits, confection and a beverage. The meat components are more acceptable when heated, but they may be eaten cold if the situation demands. Hot or cold water may be used in making the beverage.

Field Ration C

Breakfast* B Unit	Dinner* B Unit	Supper* B Unit
Biscuits	Biscuits	Biscuits
Confection	Confection	Confection
Sugar	Sugar	Cocoa beverage
Coffee, soluble	Lemon powder (syn.)	

* Can of meat and beans, meat and vegetable stew, meat and vegetable hash or other meat combination.

The K ration is the best known of all the army diets, yet few people know its composition. This highly concentrated combat ration is an outstanding achievement of the Subsistence Research Laboratory. Packed in three moisture-proof, gas-resistant, non-metallic boxes, for three meals, it weighs only 32.8 ounces, and represents 3,725 calories. It is very resistant to temperatures between 135° and −20°F. The keeping qualities of the ration are shown by the data (95) on thiamin losses after storage for four months, given in Table 20.

Field Ration K*

Breakfast Unit	Dinner Unit	Supper Unit
Ham and eggs	Pork luncheon meat	Veal luncheon meat
Biscuits	Biscuits	Biscuits
Fruit bar	Concentrated bouillon	Chocolate bar
Soluble Coffee	Malted milk dextrose tablets	Sugar, gum, cigarettes
Sugar, gum, cigarettes	Gum, cigarettes	Lemon juice powder

* Various other meat combinations are used for variety.

The life-giving qualities of these fighting foods were dramatically described by Mary I. Barber (124), Food Consultant to the Secretary of War:

For two days after landing on Attu, our soldiers lived on the K and D Rations. The terrain is rugged, the climbing steep; uniforms and boots were wet; the cold became colder as altitude increased. Every pound of food along with cooking utensils and stoves had to be carried up the slippery tortous paths by soldiers from the Quartermaster Corps.

TABLE 20

EFFECT OF STORAGE FOR 60 AND 120 DAYS AT 104°F. ON THIAMIN CONTENT OF 9 K-RATION MEAT COMPONENTS

	Fresh	After 60 days	After 120 days	Loss in first 60 days	Loss in second 60 days	Overall loss in 120 days
	mg./100 gm.			Per cent		
Corned pork loaf	.154	.088	.067	42.9	23.9	56.5
Veal and pork loaf	.055	.034	.025	38.9	26.5	54.5
Pork luncheon meat	.425	.253	.159	40.5	37.2	62.6
Chopped ham and eggs	.200	.138	.091	31.0	34.1	54.5
Corned beef, minced	.018	.014	.010	22.2	28 6	44.4
Chopped beef and egg white	.017	.014	.011	17.6	21.4	35.3
Chopped pork and egg yolk	.130	.082	.063	36.9	23.2	51.5
Chopped pork and egg white	.208	.135	.089	35.1	34.1	57.2
Beef and pork loaf	.051	.041	.028	19.6	31.7	45.1

The first food to reach the troops was ration C. Some men had small alcohol stoves so that water could be boiled for coffee or hot lemonade, and the meal units could be heated, if time from battle allowed this to be done. The little stoves had to be buried in the mud and shields put around them to hide their dim light. Later, the large, heavy gasoline burners from the Army field ranges arrived. From then on, hot coffee and cocoa were available at all times for those who could get to the improvised field kitchen.

Several days later other food supplies arrived: canned meat and canned dehydrated vegetables, fruit juices and soup. All these items were carried by men, but at last our soldiers, miles from the supply base, were eating hot, nourishing meals.

Contrast a tropical combat area with Attu. Here the heat seems unbearable. Uniforms are soaked with perspiration; water may be scarce and what there is may be warm and taste queer. The problems of the

Quartermaster Corps are many and complicated. Every precaution must be taken to prevent food spoilage. Each item shipped must withstand the terrific heat of the tropical sun and the dampness due to the rains. In the tropics, as in the Arctic, rations K and D are of great importance. K is the ideal combat ration, the food on which men fight and fly. It is the ration which keeps body and soul together and gives our soldiers strength over that of the enemy.

Rations were prepared for life rafts, both the rafts carried on ships and the inflatable rubber rafts with which aircraft are equipped. Combat lunches were developed for bomber crews and special duty rations were formulated for temporary use in the jungle, mountains and desert warfare.

The "10-in-1" ration is packed in one box and provides a balanced diet for ten men for one day. It was designed to facilitate distribution of food under combat conditions and may be issued to groups of from 5 to 5000 men when they leave their base camps. The Subsistence Research Laboratory described the ration:

> It consists of canned, evaporated and dehydrated foods. Five different combinations of food components are cased to eliminate the monotony of diet. The combinations are designated as Menu No. 1, Menu No. 2, Menu No. 3, Menu No. 4 and Menu No. 5. The components are assembled in a hard, fiber case in four boxes, two of which are wax dipped and contain items that can be damaged by water. The other two contain the canned items. One box of canned items and one waterproofed box supply rations for five men. Preparation of the meals on each menu is relatively easy and the food for each noon meal may be consumed without the necessity of cooking.

The menus provided in the 10-in-1 ration are shown in Table 21.

In certain combat areas it was possible to meet only the minimal nutritional requirements of the men during the active phase of the campaign. The tropics presented almost insurmountable difficulties in addition to those of supply and preparation. The efforts of the dietitians, nutritionists and physicians of the Surgeons General's departments and of the Services of Supply made the conquest of places like New Guinea possible, for with less medical service and planning

for nutrition, our troops might have been defeated by climate, disease, and lack of proper nourishment.

TABLE 21

10-in-1-Ration

Food Groups	Menu 1	Menu 2	Menu 3	Menu 4	Menu 5
Milk	Evaporated	Evaporated	Evaporated	Evaporated	Evaporated
Vegetable	Baked beans, dehy.	Beans, snap, canned	Peas, canned	Sweet corn, canned	Beans, lima, canned
Fruit	Jam, canned Pineapple-rice pudding, canned Tomatoes, canned	Jam, canned Fruit bars	Jam, canned Fruit bar Orange powder	Jam, canned Lemon powder	Jam, canned Grape juice powder
Eggs	Egg product, canned, (Ration K)	(Ration K 2)	Ham and eggs, canned (Ration K 3)	Egg product, canned (Ration K)	Bacon and eggs, canned
Meat	Pork sausage meat, canned Meat and vegetable (Ration K)	Bacon, sliced, canned Stew, English style, canned Cheese, canned (Ration K)	Beef, corned, canned Meat, canned (Ration K)	Bacon, sliced, canned Beef, roast, canned (Ration K 4)	Hash, corned beef, dehyd. Cheese (Ration K) (Ration K 5)
Cereal and bread	Biscuits, C square Cereal, pre-mixed	Biscuits, C square Cereal, pre-mixed	Biscuits, C square Cereal, pre-mixed	Biscuits, C square Cereal, pre-mixed	Biscuits, C square Cereal, pre-mixed
Butter	Army spread	Army spread	Army spread	Army spread	Army spread
Beverage	Coffee, soluble, canned	Coffee, soluble, canned	Coffee, soluble, canned	Coffee, soluble, canned	Coffee, soluble, canned
Salt and sugar	Salt Sugar	Salt Sugar	Salt Sugar	Candy, hard Salt Sugar	Chocolate Bar (Ration D) Salt Sugar

A letter from a medical officer, Maj. Glen L. Williams, M.C., stationed in Africa gives his reaction to Army rations.

At the present station the food is excellent and very nourishing, more so than the average civilian meal at the present time, and we have fresh vegetables daily from our own garden. There is a lack of citrus fruits but there are some canned juices available. Grapefruit juice seems to be a favorite as it retains a flavor which simulates the original. Orange, on the other hand, though it appears to be nourishing has a sad taste as compared with the original. The boys drink it and like it though, even

though it is not nearly as good as grapefruit. Pineapple is excellent, though it is too sweet most of the time and one must have some water available to top it off. I do not know how much such juices are found on the actual line, but hear that some get up pretty close. The boys at the front like to get the food served at the hospitals and you always hear plenty of slang about Spam and Vienna sausages. Some would walk a mile for a good hot dog as known at home.

The C ration is a bit clumsy to carry and really represents one of the first attempts to put up a good ration in a small space; it was not small enough or handy enough to handle. All is good and quite palatable if one has to make only a few meals on it. If you have to go any length of time and know that other foods are available, it is pretty rough. The meat and vegetables are much better if hot or well warmed, but can be eaten cold and are still good, though one would get tired of them quickly.

The K ration is a further step in putting up a variety of goodies in a very compact space, with a larger variety of food ingredients well preserved and practically lacking moisture. One must have a goodly supply of water to be able to like the K ration, but if that is available one has a real treat, at least for a time. There is chewing gum in one and cigarettes in two of the packages, added attractions to make a man's diet a little more attractive. The dehydrated vegetables and the canned white potatoes have their place and are very acceptable, but here the experience and training of your cooks is of very prime importance. I have seen shoe-strings made out of the chips of dehydrated potatoes that would make a bride jealous to taste them and compare them with some made from fresh cut potatoes; on the other hand I have seen equally sad results when care was not taken to dehydrate them properly and to prepare them correctly. I have had mashed potatoes which were excellent, only because the cook took pride in getting out a good product, as I have seen the same food mangled by others. When properly prepared, dehydrated vegetables are satisfactory substitutes in most respects and fill out the menu very well. I like the dehydrated cabbage, properly prepared, much better than fresh cabbage, as I do not get nearly so much indigestion after eating it. I have heard similar remarks from other men.

As for powdered eggs, they have their place but will never replace fresh ones. Again, when properly prepared they make a grand dish, especially if some ham, bacon or other good meat is fried properly and mixed into them at just the right time and if they are served at just the right moment. It is easy to cook them so that you can hardly cut them with a knife, but a good cook will see that they are served properly. As a whole, I have seen very few people who have not gained weight on the regular ration and have enjoyed it even though they do a whole lot of cussing about it.

Navy Rations

The problems of feeding Navy personnel are considerably different from those involved with land forces. At the Naval Medical Research Center at Bethesda, Maryland, the nutritional considerations relating to the many special problems confronting a navy were studied. Experts and officials of the Army, Navy, Marine Corps, Coast Guard and Merchant Marine worked in close cooperation with the Committee on Medical Nutrition of the National Research Council. The committee was able to obtain quickly the best available opinion on scientific matters and to plan tests for developing the answers to problems that needed experimental investigation. Investigations were carried out in the research centers of the Army or Navy, and in university laboratories under contract with the Office of Scientific Research and Development. The adequacy of the diets provided for our forces afloat is evidenced from the figures presented by Brown (125) and shown in Table 22.

The following excerpts were taken from an unpublished paper "Aleutian Alimentation" prepared in early 1944 by

TABLE 22

DAILY ISSUES OF SPECIFIC NUTRIMENTS FOR SERVICE MEN

Man (70 Kg.)	National Research Council	U.S.S. Arizona*	U.S.S. Arizona†	Base Force, Pacific Fleet‡	Nine Corps Areas U.S. Army§
Total foods, lbs	......	6.1	......	......	5.5
Calories—moderately active	3,000	4,118	3,089	4,620	4,150
Protein, gm	70	145	109	139	132
Calcium, gm	0.8	0.92	0.7	0.84	0.97
Iron, mg	12	27	20	32	25
Vitamin A, (I.U.)	5,000	16,460	12,345	15,125	12,000
Vitamin B_1, mg	1.8	3.21	1.8	2.60	2.74
Vitamin B_2, mg	2.7	3.52	2.8	2.80	2.57
Vitamin C, mg	75	150	89	190	140

* For a period of one year for 1,200 men.

† For a period of one year for an average of 1,200 men; calculated on the basis of an assumed loss of 25 per cent in preparation, table waste and spoilage; additional corrections for preparation and cooking losses applied in the case of vitamin B_1 and C.

‡ Based on provisions issued for 1,000 men for a cruise of thirteen weeks of the U.S. Pacific Fleet Base Force in 1941.

§ Based on a study of menus for nine Army corps areas for a period of six months in 1941.

Lt. Cmdr. Fred M. Sibley, Jr., U.S.N.R., and contribute a close view of the Navy's problems in the arctic campaign and the ways they were met:

The Navy is usually more fortunate than other units of the armed forces insofar as food is concerned. This is due to the fact that most of our vessels afloat start a cruise with provisions which will furnish during the entire voyage all the elements of a well-balanced diet, including fresh fruit and vegetables. Those naval activities which are shore-based are well provided by supply ships.

For men of my squadron, diet week of the year 1942 was the period of June 3–10, week of the attacks on Dutch Harbor. When the first Jap bombs hit the island, there was a sudden exodus from "Navy Town" to the hills. Many experiencing their first air raid discovered amazing agility and mountain climbing skill. Ballyboo Mountain was an excellent spot to run for shelter from bombs, but such large scale sudden movements of all personnel, particularly those attached to the mess halls, caused a considerable dislocation of the feeding system. Most of us who were on duty day and night had no regular chow for several days. It seems that during the air raid days the only food available was that prepared by the civilian employee restaurant of a company which was constructing buildings for the Navy. Sandwiches were brought over at chow time, with the coffee which is a "must" in the Navy diet, furnishing warmth and good cheer to Navy men when strength and morale are low during long days and nights of no sleep.

The winter of 1943 was one which will not be forgotten by anyone in my old squadron. We were based in a desolate, bleak icy waste. Early in November snow covered the frozen tundra. Men huddled around tiny oil stoves while 70 knot winds shrieked and blew snow through the cracks of our frail huts. One storm late in November lasted three days. During this time most of the men did not dare venture out to the mess hall, a quarter of a mile away, for fear of being lost in the white fury. Several men who lost their way later were found frozen to death in the snow. The only nourishment during these bad days were cans of beans and soups which surreptitiously had found their way into the huts from the galley.

It would be easy to criticize Navy food as being too starchy. There are potatoes and bread at nearly every meal but the diet is always so well balanced that Navy men thrive on it and like it. Furthermore, the meats obtained in the Aleutians now are excellent and varied and far different from 1942, when at one base we had Spam and potatoes nearly every day for two months. The menu was varied only by the substitution of powdered eggs and dehydrated potatoes and Spam. The fact that I had never liked this food did not serve to increase my affection for it.

I believe I have been very lucky to have as good food as we have had in the Navy. We were not required to subsist on cans of synthetic rations, or on the 'fat of the land,' which would have been 'lean' in the Aleutians. We had all the luxuries of home when they were available. There hasn't been a Thanksgiving or Christmas when we haven't had our turkey. One thing which is well to bear in mind is that the preparation of food is just as important as the items themselves. And little things, seemingly unimportant to civilians, may be of immense help toward restoring the well being of a hungry pilot or sailor. For example, in our bombing squadron we found that when the crews were going to be gone on long missions they preferred taking a box of various tasty sandwiches and a jug of boiling hot coffee, rather than a container of pre-made hash which would be cold and unappetizing. Little things like peanut butter, jam, jelly, chocolate, canned milk and ham occupy an important place on the bill-of-fare of men at the fighting fronts. The great improvements in supply service to different bases and the additions to Navy diet of many new foods, dehydrated, quick-frozen, or fresh, have done wonders in providing a nourishing and tasty well-balanced diet. The Navy's supply corps has done a 4.0 job in giving Navy men the right food to sustain them as the finest fighting men in the world.

Local food is not available in the Aleutians, where nothing grows. In spite of an abundance of salmon, trout and ocean fish, this is rarely served because there are no facilities for catching fish. Furthermore, the majority of sailors seem to dislike fish, whereas everyone likes meat.

Gift boxes from home arrived constantly. Cookies, fruit cake, candy, canned meats and fish were the main items and very welcome. For some reason people in the Aleutians feel a tremendous craving for sweets. I felt a great desire for candy, which I hardly ever ate at home.

Field rations fortunately are not used by ships or shore-based naval units. Flight rations of patrol planes vary according to the airplane used. A Catalina has facilities for cooking eggs and ham and beans, which is excellent for air crewmen on long flights. Other aircraft are able only to take sandwiches and coffee in thermos jugs. Emergency aircraft rations consist of brandy, morphine, cigarettes, K rations and water. There have been stories written on how to live off the land in the Aleutians, but this would be most difficult in that rugged, barren land. Various ingenious ways were devised of procuring food items when stocks ran low. In general the most successful method was to be on friendly terms with the local representative of the Army Quartermaster. The Army in the Aleutians has always cooperated with the Navy amazingly well to supply badly needed items of food and clothing. There were some periods, even in 1943, when Navy messes ate Army food almost entirely.

Food Fights for Freedom

The American soldier is as ingenious as he is fearless. On Bataan the soldiers of the Quartermasters Corps cut and threshed rice in order that the fighting men could have food as long as possible. From Guadalcanal come tales that when there was no water, the soldiers knocked cocoanuts from the trees and drank the milk. The "ice cream habit" of the American people lives on even in the face of disaster. From arctic areas there are stories of soldiers mixing up powdered milk, eggs, sugar, water and vanillin in a dish pan and freezing it outdoors, thus satisfying their tastes for ice cream and their thoughts of home.

Providing food for the number of men fighting a global war is a colossal undertaking. The figures in tons and dollars strain the power of comprehension. When the army alone reached 7 million men, Colonel Paul P. Logan, Quartermaster Corps, stated that the expenditures averaged more than $4,000,000 daily, to provide each soldier with about five pounds of food per day. The daily 21 million meals would require more than 30,000,000 pounds of food.

The philosophy back of the entire feeding program was well expressed by Mary I. Barber (124): "The American soldier must have food—food that cheers and warms him—food that renews his fighting strength and spirit—food that satisfies his hunger—food that brings to mind his home and reminds him that he is struggling to maintain just such a common need as three meals a day—three meals a day eaten in peace; eaten at a table with the ones he loves best—eaten without fear, eaten with freedom from want."

Food for our soldiers and sailors was the best food the land can produce and in spite of the shortages of transportation and packaging materials, our fighting men received, and ate, much more food than they ever ate in civilian life. The nutritive value, palatability and attractiveness of the food served to armed forces in the last analysis rests with the cooks and the bakers. The procurement program was paralleled by the careful training of more than a quarter-million cooks,

bakers, mess sergeants and mess officers whose jobs were to prepare and serve the most palatable, nutritious and satisfying foods possible under every type of military service.

Contrary to barrack's conversation and army jokes, a survey by the Director of Morale of the War Department Services Division revealed that most soldiers were satisfied with their food. As a matter of fact, four-fifths said it was good. It is common knowledge that most men who enter the services soon begin to complain about tight fitting clothes. One survey showed that 2 out of 5 soldiers complained that their trousers were too tight for comfort and military activity. Weight gains were as much as 15 to 20 pounds during the first two months.

Evidence amassed shows that the wounded had far better chances of recovery than those in preceding wars. Figures compiled by the services and released in 1944 show that of wounded men in the Army, about 3.5 per cent died; in the Navy, 3.16 per cent; in the Marine Corps, 3.15. In World War I, the mortality was: Army, 6 per cent; Navy, 7.35 per cent; Marines, 12 per cent. Thus one bright spot was recorded in a general picture of horror, for it cannot be denied that this first total global war killed outright far more fighting men, not to mention civilians, than any of its lesser predecessors. Also, advances in medical and surgical science were responsible for halving the number of deaths from wounds. It is generally recognized that nutritious foods and the excellent nutritional status of the soldiers contributed in no small measure to more rapid recovery of casualties.

Miss Barber made it clear that the Army shared with the civilians the responsibility of avoiding waste. She stated in 1943 that:

> Looking back at menu-making nearly three years ago, the work was comparatively simple. Our country was one of food abundances and surpluses; now it is one of unavailabilities and shortages. Every effort is being made to conserve food on all army posts. The chief improvements are a change in the number of rations issued and a new Food Service Division. Formerly, one ration was issued daily for every man assigned

to a mess. Now, rations are issued only for the men who actually eat their meals in the mess. The mess officer can estimate, from experience, how many will be absent because of sick call, trips to town or furloughs. This has cut down over preparation of food.

She paid tribute to our soldiers and to the significance of the mess kit in the following words:

Many of you have read about the cemetery in Guadalcanal where Protestant, Jew and Catholic are buried side by side, each grave marked with a concrete block. Preserved in this block is the soldier's mess kit—the most intimate personal belonging he had through all his fight for the freedom of the world. . . . Today the mess kit, significant of the strength and courage gained through food, is the symbol both of the home and the battle field. It means food—food that will sustain and nourish our soldiers while away from their families and usual environments and keep them adequately fed until the guns are stilled and life again means planning for a lasting peace.

Chapter Eleven

FOOD FOR THOUGHT

Food, agriculture and nutrition are now considered basic factors in international relations. Indeed, these subjects served as the central theme of discussion at one of the most important international conferences ever held in any country. The United Nations Conference on Food and Agriculture (Hot Springs, Virginia, May 18 to June 3, 1943) was called to consider the goal of freedom from want in relation to food and agriculture. In its resolutions and its reports, the Conference recognized that freedom from want means a secure, an adequate, and a suitable supply of food for every man. Recommendations were unanimously adopted by the representatives of forty-four governments which may profoundly affect more than two billion people around the globe, and determine the kind of a world in which they will live. Dr. Frank G. Boudreau (126), Chairman, Food and Nutrition Board, National Research Council, and Technical Secretary, Section I, United Nations Conference, stated:

At this period in the history of the world no one needs to be reminded that food is the most fundamental of human needs. In parts of Europe and Asia food is the first thought of millions of human beings when they wake up in the morning; craving for food accompanies them throughout the day and food is the subject of their uneasy dreams during the night. The destruction of food crops and food cargoes, the interruption to the normal transport of foodstuffs on the land and sea, and the withdrawal of millions of farmers and farm laborers for service in the armed forces, have led to widespread starvation and undernutrition. Obviously, the first task of the United Nations, when the enemy is driven out of any country, will be to feed the hungry. No peace will have any meaning for these suffering millions, until their hunger is satisfied. The pledge of the United Nations to make stores of food available to the occupied countries as soon as hostilities cease is a political weapon of first importance. The thought that bread and meat and milk will be available once more when the Axis is defeated must steel many a weary arm to carry on

the struggle against the occupying forces. Hunger will lead to the greatest civil disorder in occupied countries when Axis forces are withdrawn unless arrangements are made for the immediate distribution of food.

The time is long overdue for considering costs in terms of human lives and well being. Poverty and malnutrition go hand in hand, so it was decided by the United Nations Conference (127):

> . . . the incidence of disease in general and the mortality rate among infants, young children, women in the child-bearing period, and indeed among all age groups, are invariably higher in ill-fed than in well-fed populations. Recovery from disease is more prolonged when the diet is defective. Countries which consume the best diets have the lowest rates of mortality and the highest expectation of life. . . .
>
> . . . Malnutrition in varying degrees is found in all classes and countries, but more particularly it is the close and constant companion of poverty both national and individual. Poverty almost invariably means a poor and insufficient diet, and the latter is the main cause of the disadvantage of the poor in respect to health, so clearly shown by statistics of disease and mortality.
>
> . . . There has never been enough food for the health of all people. This is justified neither by ignorance nor by the harshness of nature. Production of food must be greatly expanded; we now have knowledge of the means by which this can be done. It requires imagination and firm will on the part of each government and people to make use of that knowledge.

Never in the history of the United States has the subject of food been so important. During and immediately following World War I, food exports increased. Responsibility for this increase was equally divided between higher production and changes in civilian consumption. The period intervening between the two great world conflicts was characterized by overflowing granaries and underfeeding of a large part of the population. The producers were concerned with food surpluses; the government bought and stored surplus, and subsidized restricted production. Pigs were destroyed by the million, coffee and wheat were used as fuel, other foods were likewise destroyed, and tariff barriers were raised against food imports. Simultaneously, the economic depres-

sion befell the nation, reducing buying power until hunger and undernutrition were widespread. Although the public talked about food surpluses, the real trouble was the consumer's inability to buy, rather than overproduction. When employment increased after Pearl Harbor, consumption rose and the food surpluses disappeared.

Physiologic Needs of the Common Man a New Goal

National economic policies with regard to food supply are now being related, not so much in terms of dollars and cents but in terms of satisfying the physiologic needs of the common man. The United Nations Conference (127) declared its belief "that the goal of freedom from want of food, suitable and adequate for the health and strength of all peoples, can be achieved."

The ultimate goal of the science of nutrition is to provide a standard of dietary intake that will allow amply for the health and well-being of the human race. In attaining this goal, the individual requirements in terms of amount and proportion of essential nutriments and the methods of supplying them must be considered. Individuals or groups of individuals may have an adequate consumption of dietary essentials during their life span, but before and during fetal life, long before his birth, the mother must have had optimal nutrition to insure her offspring his rightful heritage. The knowledge of the nutritive requirements of the human body for health and growth has progressed rapidly in the past few years. The basic requirements have been formulated, and although much still remains to be learned under the changing impacts of modern civilization, the knowledge is far ahead of its application to the welfare of humanity.

On the basis of the Recommended Dietary Allowances of the National Research Council, the daily nutriment needs of a world population of two billion human beings consuming a diet of natural foods can be approximated. The values for a moderately active male weighing 70 kilograms (154 pounds) can be used as an average. The requirements for children

and women would be smaller, but those for adolescent boys, and women during pregnancy and lactation and for individuals doing heavy work would be equal or greater. A world population of two billion human beings, therefore, requires approximately six trillion (6 million million) calories of food energy daily, 140 million kilograms (309 million pounds) of protein, 1.6 million kilograms (3.5 million pounds) of calcium, 24,000 kilograms (53,000 pounds) of iron, 10 trillion (10×10^{12}) units of vitamin A, 3600 kilograms (7937 pounds) of thiamin, 5400 kilograms (11,905 pounds) of riboflavin, 36,000 kilograms (79,366 pounds) of niacin, and 150,000 kilograms (330,693 pounds) of ascorbic acid.

If these figures seem astronomical, consider that these materials not only must be supplied for every day of the year but must be obtained from material grown during not more than half the year, on the average. However, with our present knowledge of nutrition and food production, this objective can be attained provided the peoples of the world cooperate, the necessary leadership and statemanship are forthcoming, certain food habits and taboos are eliminated, and all the available scientific knowledge is applied. It is possible, on the basis of present agriculture practices and the amount of cultivatable (arable) land available, to produce the quantities of food necessary to supply the essential nutriments but radical changes will be necessary in the use of our land resources. If there are four billion acres of land in the world which are suitable for crop production, theoretically each living individual is entitled to the produce from about two acres of land. The Bureau of Agricultural Economics (71) has estimated that an acre of land yielding about 12.4 bushels of wheat would more than supply an individual's yearly nutriment needs.

From the figures given above for the calorie requirements of two billion people, it would require approximately 1.9 billion acres of wheat to furnish the energy demands of the world population. More than the estimated requirements

for protein, minerals and vitamins would be supplied by this acreage if all the wheat was used to feed people and all of its nutriments were retained in processing and preparation. If soybeans were grown instead of wheat, less land would be required, since soybeans would provide more nutriments per acre than does wheat. On the other hand, if the land were used for production of whole milk, it would take three times the acreage to produce the equivalent amount of nutriments. The average production of a dairy cow in the United States has been given (128) as 4,700 pounds of milk per year. It would take, therefore, approximately 272 million of such cows to produce the 3.5 billion pints of milk per day which would supply the calcium needs of the world populace.

TABLE 23

Daily per Capita Nutritive Value of Food Supply (129)

1930–39 average

	Energy, Cal.	Protein, Gm.	Calcium, Gm.	Iron, Mg.	Vitamin A, I.U.	Vitamin C, Mg.	Thiamine, Mg.	Riboflavin, Mg.	Niacin, Mg.
Total from all sources (uncooked basis)	3,260	89	0.86	13.9	6,550	93	1.81	1.97	17.8
Recommended dietary allowance (N.R.C.) for man weighing 70 kg	3,000	70	0.8	12..	5,000	75	1.8	2.7	18..

One of the important lessons learned from the war is the relationship among economic level, food production, food distribution and food consumption. The so-called food surpluses of the 1930's really were not surpluses but the results of underconsumption, which rapidly disappeared with the rise in family incomes. War brought food shortages and rationing despite the greatest agricultural production this country has ever known. As income rose and civilians were able to buy more food, millions of youths were called to the armed forces and began receiving the best food possible. The records of medical examinations of the inductees have all indicated the toll that the false "surpluses" of the depression exacted in degrading the nutritional status of our best manhood.

The world cannot live on wheat, milk or soybeans alone and other factors would also make impractical any scheme such as outlined above, but the potential resources are present for producing the food necessary to supply the requisites for optimal nutrition of the populace. The people might not get all the meat or milk they would prefer, but they would have a varied and complete diet, even with the increased percentage of cereal products. Everyone could have the food his body needs if land were used to produce the nutrient essentials instead of "best-selling" or "highest-profit" produce.

Though the world has the facilities to produce the food required, this does not assure everyone enough to eat. The United States has over 2.5 acres of arable land per capita and the estimated production of nutriments, in terms of food, is sufficient to supply the entire populace with an adequate diet (Table 23). In the past several years there has been an overall improvement in the diets consumed by families at different income levels as the result of increased consumption of milk, eggs, fruit, and vegetables, highly nutritious, protective foods and the most expensive. For the world as a whole, the problem of food supply in relation to population is a debatable question. There is no question but that food supply must increase with increased population. Nutrition is a much broader problem however than food supply alone, or of meeting the food demands for existence. It is one of providing each and every human being with a food supply adequate for optimal health. Within the past century and a half the world population has more than doubled, largely as the result of man's increased efficiency in the harnessing of sources of power and his ability to produce additional food. In this country approximately 20 per cent of the population derives a living directly from agriculture and food production. In Asiatic countries such as India and China, over three-quarters of the population live by agriculture. The pressure of population on food supply in the latter countries is so great that famines and starvation continually are recur-

ring. At best, the people never have enough to eat, let alone a good diet. The possibility of increasing food production in these countries is remote. A change in the types of crops raised would enhance the quality of the food, but probably at the expense of quantity. The solution for these countries appears to lie in greater industrialization, with the conse-

TABLE 24

NUTRITIVE VALUES OF FARM PRODUCTS AND AVERAGE OUTPUT OF NUTRITIVE UNITS PER UNIT OF RESOURCES USED*

Farm Product	Nutritive units per 100 lbs. of farm products	Nutritive units obtained per acre of land and per 100 hrs. of labor	
		Land	Labor
Animal			
Whole milk	19.6	226	508
Eggs	47.2	113	245
Hogs	65.2	201	650
Cattle	29.0	27	180
Plant			
Wheat, whole flour	63.8	475	5274
Corn, corn meal	18.6	181	663
Potatoes	15.6	1179	1734
Soybeans, whole	116.7	1260	10503
Peanuts, whole	60.9	411	709
Cabbage	25.6	3277	3006
Carrots	65.2	11671	3602
Tomatoes	25.8	1504	890
Apples	7.0	363	295
Oranges	24.2	3253	2085

* Equal values are placed on the various essential nutriments in the proportion required according to the recommended allowances of the National Research Council. The per capita requirements for 10 nutriments (food energy, fat, calcium, iron, vitamin A, thiamin, ascorbic acid, riboflavin, and niacin) are given a valuation of 100. Equal weighing for each nutriment is assumed, and the valuation of the product derived by computing the percentage of the daily recommended allowance supplied by a pound, adding these percentages, and dividing by 10, the number of nutriments.

quent exportation of manufactured products and the importation of foodstuffs.

Dr. Raymond P. Christensen of the Bureau of Agriculture Economics, U.S. Department of Agriculture (71) has calculated the relative nutritive values of various farm products and the nutritive units obtained per unit of farm resources.

The data in Table 24 illustrate the relative efficiency of farm resources devoted to different food products. Christensen pointed out several shortcomings in this method of calculation. Equal weight is given each nutriment and overlooks the relative values of different nutriments, particularly in the prevention of deficiency disease. The values are derived from analyses of uncooked food and take no account of relative differences in cooking losses. Probably most significant is the fact that this method of valuation does not account for the relative worth of certain foods over others in their ability to supply minerals and vitamins in concentrated form. Some foods contain certain of the nutriments in such low concentration that it would be impractical or impossible to consume the quantity necessary to supply all of the requirements. Despite these shortcomings, however, this comparison of the relative ability of different farm products to supply the human dietary needs furnishes a basis for evaluating the potential possibilities of agricultural production in meeting the nutritive requirements of the world population. Of all the animal products, milk furnishes the most nutritive value per acre of land, but supplies less per unit of labor than hogs. Wheat and soybeans are outstanding in their yield of nutriments per unit of labor but are less than some other field crops in yield per acre. As pointed out by Christensen (71):

> Food output from available resources will be maximized when marginal outputs of each product contribute to total food needs per unit of resources used. In normal times prices may be relied upon to a much greater extent than at present to bring about the adjustments in use of resources necessary to supply food needs as fully as possible. However, in a period of increasing food needs the values placed on products to guide the use of resources should depend upon the value of each product in helping to meet food needs as measured in terms of essential nutrients.

The United States is in an enviable position among the nations of the world with regard to population density and potential food resources. By slight adjustments in our agriculture and more efficient use of our land resources we can supply all our people with food that will meet their needs

for optimal nutrition. Present population trends in this country may be offset by the scientific advances in agricultural production, although we are approaching population saturation under present agriculture practices. We have over two acres of arable land per capita of population, but some cannot be profitably used at present. Rejuvenation of this land will take time. In the meantime, other lands may be made productive by irrigation. Greater production also can be expected from the best soils which are already under cultivation. The former director of the Agriculture Research Administration, Dr. E. C. Auchter (128) pointed out some of the ways this is being done. For example, the planting of hybrid corn, which consistently outyields the open-pollinated varieties by 20 per cent, makes possible a one-fifth greater production of corn without using more acres of land or manpower. In 1942, 630 million bushels of corn were added to our total production by using hybrid seed corn. Among our 26 million dairy cows, with an average production of 4,700 pounds of milk per year, are some 800,000 cows which produce an average of over 8000 pounds of milk a year. The average annual production of the test cows in the Department of Agriculture herd at Beltsville, Maryland, is about 16,000 pounds, but the present world's record production is 41,943 pounds. Although these superior cows are better fed and receive better care, most of the credit for their production achievements should go to better breeding. The theories of genetics are as applicable to animals as to plants and their practicability and far reaching potentialities are accomplished facts. The proved-sire method, together with the technique of artificial insemination, provide the means for even the most isolated farmers to improve the production qualities of their livestock.

Nevertheless, the fear of certain prophets that increasing the food supply to certain overpopulated areas such as Asia will only cause a further increase in population is not a figment of the imagination. This is undoubtedly true and there appears to be no question that we should look first to the mending of our own fences. On the other hand, the world

in the past decade has shrunk considerably in size and the fact must be faced that peoples in distant corners of the earth are now neighbors. The security of local groups now depends on the security of the whole. Optimal nutrition is the fundamental basis of good health and to protect ourselves we must consider the nutrition and health of our neighbors.

Population pressure on food supply can be relieved by several procedures. Increased production of food is only one, possible in certain areas, but in those where it is most needed it does not offer any hope under present conditions. In Asia there just doesn't appear to be enough land. Emigration is another way. But few areas are available for receiving large numbers of people. The earth appears circumscribed and new lands with potent agricultural possibilities are limited. Another way is industrialization—exchange of manufactured exports for food imports. This appears to be the best solution under present circumstances. There is, from the estimates, the two acres of potential land production available for each member of the world's populace. Means of utilizing it to its utmost productiveness and of distributing the food thus produced would have to be organized on a world-wide basis. Attempts have already been made in this direction with the first Allied Food and Agriculture Conference.

Ultimately, however, we must look to some form of population control. Agriculture science has great potentialities for increased production of the food resources of the world, but in terms of the fecundity of the human race it seems certain to come out wanting. If we are to reach and maintain an adequate diet for the populace of the world, some restrictions must be placed on the ultimate demands that will be made on the limited resources available. If science is ultimately able to circumvent the green plant in capturing the energy of the sun, agriculture may be displaced as the method of food production. Although the green plant is still the most profitable way known to man at present for capturing solar energy, the efficiency is only several per cent. The possibility that man can eventually supplant the

green plant is not as fantastic as it first appears. Many of the dreams of the ancient alchemists have come true with the modern success of chemistry and physics. Atomic energy is more than a mathematical formula. As a distinguished Chinese scientist, Pei-Sung Tang (130), recently suggested:

> It is not mere wishful thinking that in the generation that lies ahead of us, we may understand enough about the fundamental process of photosynthesis of the green plant to be hopeful of liberating ourselves some day from the toil of agriculture as practiced now . . . When that time comes, man will be independent of the limited two dimensional land area for the cultivation of his crops for food and power. He may, by using the earth as his crucible, the sun and the atoms as his furnace, and the air, soil, and oceans as his reagents, elevate himself from slavery to the status of a Titan. Man will then enjoy an age of abundance and prosperity, free from muscular labor and strife. He will be given a respite from his constant fight against his crops, his animals, and his machine for the limited land area. Until that time comes, however, man will still have to depend on agriculture as practiced at present for food and power. He will still not be freed from the constant struggle for space. This struggle can, however, be alleviated temporarily in certain ways, aside from the usual practice of improving the soil, crops, cattle, and the prevention of diseases, and the much advocated limitations on population growth. One of these is the more extended use of the seas and oceans in which are stored vast wealths of animals and plants, and about which the young science of oceanography may have much to tell us in the future. Another possible measure for the more economic use of land lies in the establishment of a world state in which a scientific and rational regionalization of agriculture may result in a more efficient production of agricultural products through fuller utilization of the natural distribution of climate and soils of the world, unlimited by artificial political boundaries between the nations.

Food Supplies Are Now Considered in Terms of a Balanced Diet

In World War I emphasis was placed upon the caloric and protein contents of the foods produced. Nutrition greatly advanced in the intervening years and today equal consideration is given to calories, but the proteins must now be considered in terms of the essential amino acids they furnish, and the term vitamin now designates a large number that are soluble in water and an equally important group associated with fat. In addition, other constituents such as essential fatty acids and choline are known to be necessary for the maintenance of health. In World War II foods were planned

for their entire nutritive value and economists are now beginning to calculate the food supply in terms of nutritive value instead of economic value alone.

People who live continuously on diets providing less than the minimum daily requirements may not be able to stand the stresses and strains of living. Any diet that fails to furnish the average amount of each of the nutriments needed to maintain the body should be labelled as unsafe nutritionally. As in other ventures in life, everyone needs a margin of safety. Bad environment, including poor food, is one of the most frequent deterents to good health and efficient living. Indeed, the late T. Wingate Todd (131) emphasized that adult man is "the outcome of growth enhanced, dwarfed, warped or mutilated by the adventures of life."

It is reassuring to know that Americans were better fed during than before the war. Dr. Russell M. Wilder (113) of the Mayo Clinic and associated with the food and nutrition problems preceding and during the Global War, tallied up our food supply and the demands on it. He found reason to believe we had less hunger in America than before the war. He pointed out that we did not have all the kinds of food that everybody wanted, but we had the foods to keep vigorous and healthy if we used them wisely.

While Dr. Wilder warns that our food problems are genuine, troublesome, and serious enough, and no end of them in sight, he does assure us that there has been no "food crisis" worthy of the phrase, and none will need to arise. This opinion is verified by Dr. John D. Black (70) of Harvard University who states that we will have *Food Enough* if we apply our newer knowledge of agriculture and distribute our foods wisely. Federal standards for flour and bread is an attempt to enhance their thiamin, riboflavin, niacin and iron contents to the natural level found in the whole grain, margarines are fortified with vitamin A equal to that of a good summer butter. Food sources of vitamin C—fruits, home grown vegetables—will go a long way in meeting the full requirement of a balanced diet and therefore good health.

The Attributes of Health

Optimum nutrition and health have taken on a new and more significant meaning today. No longer is optimum nutrition construed in the narrow meaning—"absence of obvious disease" but includes much broader and more positive attributes, such as stamina, efficiency, reserves and capacity. Such factors as race, heredity, climate and endemic disease may contribute to poor physique, low power of endurance and resistance to disease. But over and beyond these, the nature of the diet is most important. In animal husbandry, the factor of financial gain caused the recognition many years ago of a difference between "just adequate" and optimum health. It has been demonstrated that an increased biological efficiency reflected in superior production of eggs, milk, wool and meat, material results which can be evaluated in dollars, makes a convincing demonstration of the profitableness of better feeding. On purely biological grounds, one would expect analogous benefits to man as measured in better health performance.

Demonstrations just as spectacular as those with animals have been made on man. Recent studies on the effect of prenatal diets on child-bearing have demonstrated that good diets pay dividends in improved health for the mother, in greater nutritional stability in the infant, less loss and suffering on the part of the mother during and following birth of her offspring and fewer incidences of illness of the infant. Improved school lunches, including extra milk and protective foods, have been demonstrated to improve general health and stimulate greater growth in school children. A state of avitaminosis depresses well-being and efficiency and can be avoided by eating a good diet. Nutritional stability is related to susceptibility and resistance to disease. The incidence and duration of illness in the low income group as measured by loss of time from work and hospital days have been reported to be significantly higher than in the higher income group (47):

> The importance of good nutrition to resistance and recuperative power is recognized by most physicians and surgeons who give attention to this

point, as well as rest, as part of general treatment. Also, in their experience, all other factors being equal, the poorly-nourished patients constitute the greatest risks.

Group Captain Frederick F. Tisdall, R.C.A.F., and his associates have made a study of symptoms of eye fatigue in the Royal Canadian Air Force personnel (132). They found tiredness of eyes, burning of eyes, a sandy sensation under the lids and lacrimation (tear production) were improved by taking additional riboflavin. The incidence of vascularization (increase in blood vessels) of the cornea among apparently healthy young adults in Canada is surprisingly high and seems to vary with the riboflavin-containing foods in the diet. Riboflavin in large dosage for a period of two months decreased vascularization of the cornea in a large percentage of cases and caused marked improvement in symptoms of eye fatigue in men exposed to glare in their flying duties. Lyle, Macrae and Gardiner (133) studied the degree of corneal vascularity and the effect of supplementing the diet with riboflavin, other pure vitamins and highly nutritious food stuffs, in 4000 Royal Air Force personnel at 10 stations in the United Kingdom and 12 overseas stations. While considering the average degree of corneal vascularity a reliable index of their general state of nutrition, his experiments indicate that other factors present in fruit and vegetables influence this condition more than riboflavin.

When war came and industry grew by leaps and bounds, the demand for labor caused incomes to soar. This prosperity was reflected in a nearly 40 per cent increase in money spent for food over six years. There is every reason to believe that this increased spending on food was accompanied by some improvement in the national diet and improvement of health. Much remains to be accomplished however.

It takes large quantities of food to feed adequately even a baby. Every housewife can tell you something of the amount of foods that people eat each week. Babies eat a half ton or more of food during the first year of life. In a study of the food consumption and growth of infants during the first year of life a few years ago the staff of the Research

Laboratory of the Children's Fund of Michigan had a concrete illustration of how much food babies actually eat. To permit 500 infants weighing an average of 8.6 pounds at five weeks to attain by their first birthday an average weight of 21.7 pounds, it was necessary to handle more than 175 tons of food (Table 25). In another study we collected and analyzed all the food eaten by children of different age levels

TABLE 25

FOOD CONSUMED BY 550 INFANTS STUDIED DURING THEIR FIRST YEAR OF LIFE

140	tons	evaporated milk (equivalent to 280 tons of fluid milk)
28	"	vegetables
5	"	fruit
2.5	"	lemon juice powder
300	gallons	cod liver oil

during eight months. The quantities of food consumed at the ages of 4, 8, and 12 years are shown in Table 26. The eight and twelve year old children ate approximately 3½ pounds of food per day; the amount eaten by the average adult civilian.

Roy F. Hendrickson (134), Chief of the War Food Administration, in discussing Food for Freedom stated that:

> Every two men in uniform make almost an extra mouth to feed, for the average soldier needs 5¼ pounds of food a day, whereas as a civilian he ate only 3½ pounds.

If in 1944 the number in the armed forces reached ten million, their daily consumption of food was 52,500,000 pounds; the food consumption for the remaining 123 million civilians was 430,500,000 pounds—a total civilian food consumption of 215,250 tons of food per day or an annual consumption of 78,566,250 tons of food. In 1942 seven percent of the food produced in the United States went to the armed forces. In 1943 that amount was doubled. Mr. Hendrickson said:

> Our experience in North Africa proved that food in the stomach did a lot toward driving Nazi propaganda from the head. Under Axis domination the people had no incentive to produce for the Germans and Italians took and ravaged without sharing and replanting. After the Allied

TABLE 26

FOOD INTAKE AT VARIOUS AGE LEVELS

	Four		Eight		Twelve	
	Per day, grams	Per year, pounds	Per day, grams	Per year, pounds	Per day, grams	Per year, pounds
Cereal						
Bread white	20	15	70	56	50	40
" whole wheat	30	24	30	24	50	40
Crackers, graham	18	14	18	14	36	29
Corn flakes or shredded wheat	30	24	30	24	30	24
Milk and cheese						
American Cheese	15	12	15	12	20	16
Milk	400	322	800	644	500	402
Butter	28	22	38	31	60	48
Animal products						
Beef—lean	100	80	100	80	100	80
Gelatin	....	....	....	....	3	2½
Egg	50	40	50	40	100	80
Fruits and vegetables						
Apple	100	80	100	80	100	80
Banana	100	80	100	80	150	121
Cabbage	25	20	25	20	25	20
Carrot	25	20	25	20	50	40
Lettuce	20	16	20	16	25	20
Orange juice	50	40	50	40	100	80
Peanut butter	16	13	16	13	16	13
Peas	....	....	....	....	25	20
Potato	40	32	70	56	120	97
Tomato juice	60	48	60	48	60	48
Sugar and honey						
Honey	....	....	....	....	15	12
Sugar	8	7	10	8	22	18
Salt	2	1½	2	1½	2	1½
Total	1138	915	1629	1311	1659	1335
Drinking water	456	367	469	377	557	448

victory food and other essential supplies were distributed—flour, sugar, milk, wheat, tea, tobacco and soap. We sent more than a million pounds of field and vegetable seeds. The people went back to their fields and gardens. The flow of food from the United States to North Africa already is dwindling and soon she may even be able to share her vegetable oils and cereals with other freed peoples.

In 1916, Lafayette B. Mendel (15), the great teacher and leader in the discovery and application of the science of nutrition, in discussing the changes in food supply as affected by the war stated:

No presentation of the problems of the food supply would be complete without an appreciation of what the growing science of physiology and the chemistry of foods is contributing to mankind. The calorie-idea in nutrition, the outcome of an understanding of the transformation of energy in the living body, has been fruitful in more ways than one. It has taught people to think of the uses of food from a more rational standpoint and has furnished an intelligible basis for constructive institutional dietetics as well as the nutrition of the individual. Food is beginning to be regarded as fuel for the human organism—something that must be provided in determinable amounts. Malnutrition and under-nutrition have received a new popular significance in the discussion of human efficiency.

This is not the place to discuss the limitations of the calorie-idea in nutrition or of some of the current conceptions of the role of the individual nutrients—the proteins, fats, carbohydrates, and inorganic salts. There is a well-founded growing belief that an important part in nutrition is played by substances which are not identical with the familiar foodstuffs mentioned and which, despite the minimal amounts thereof present in the diet, may nevertheless be indispensable for growth and the maintenance of life. They have been called "accessory diet factors" or "vitamins." We may conceive of them as stimulating certain physiological processes and as essential to certain functions.

The lubricant is quite as important to a machine as is the energy-furnishing fuel. So these diet accessories may have a peculiar usefulness. Some of them are believed to be easily impaired by heat; in the language of the chemist, they may be thermolabile. Hence the use of heat for preserving or sterilizing foods suggests new difficulties. They may sometimes be lost in the wastes of the modern technical processes, as in the milling of cereals. This has been demonstrated in the case of "polished" rice. They may be sensitive to other agencies involved in the change from fresh to salted or "prepared" or preserved foods.

These topics represent the border line of our knowledge of today. Enough facts are known, however, to justify the interest which the subject is receiving.

The predictions of Mendel have been borne out. In World War II the needs of the military forces were figured in terms of 5¼ pounds of food per man but that food contained the nutriments that will satisfy all the known physiological needs of the soldier in every type of military duty in whatever climate or weather his services take him.

Dr. Frank Gunderson, Executive Secretary of the Food and Nutrition Board of the N.R.C., emphasizes the important

advance that has taken place in our knowledge of nutrition and the special consideration now given to needs calculated on the basis of nutriment content. The "Recommended Dietary Allowances" of the National Research Council serve as the basis for calculation by the Bureau of Agricultural Economics and other agencies which balance needs against resources and plans for production. It is on such sound evidence that the estimates show that despite partial shortages of certain foods which are particular favorites, the overall dietetic quality of foods, actually being consumed by the civilians during World War II was considerably better than it was in the pre-war period. The improvement in dietary is attributed to several factors: to the improved economic status of many people due to the great activity of war industries; to the progress of nutrition education; to the very substantial contribution to improved nutrition by enriched flour and bread; and, to the fact that rationing helped to accomplish more equitable distribution.

Dietary Habits Are Improving

Diets of the people in the United States are changing for the better. Dietary surveys of the population in the low income groups, the general civilian group, of school children and the agricultural situation point up these accomplishments. The reason has been attributed to larger food production, to more satisfactory food distribution, to enlarged incomes and to nutrition and health education. The present generations are beginning to feel the impact of nutrition and health education through the press, clubs, radio, schools, parent teacher groups and labor groups. With the protective foods in greater abundance there is a noteworthy increase in the consumption of milk, citrus fruits, tomatoes and vegetables. The nation has become food conscious. New and better methods of food fortification, harvesting, processing, preservation, storage and preparation have been accepted and applied. Greater emphasis and appreciation now is placed upon the retention of the maximum potential

nutritive value of a given food by whatever way it may be treated before consumption. Much has been accomplished in this respect.

Although improved dietaries are evident in this country, especially, we must not have a sense of false security. We still have large numbers of people who are underfed and misfed. Too many people are doing without breakfast or eating unsatisfactory meals. Large numbers of people can improve their health by incorporating in their daily diets more protective foods. In attaining the four freedoms, it will be necessary to make every effort to stop the pangs of hunger first, then study the food composition and dietary customs of the peoples of the world and try to furnish the foods that will build up national diets that satisfy taste as well as physiological needs. We have the necessary knowledge in nutrition, if all is properly applied at once, to lay the foundations for a new world order within which all people will have potentially healthier and happier lives, free from hunger and fear from aggression. The newer agriculture will increase the quantity and nutritive value of the foods to be harvested and eaten and at the same time conserve the soil; the improved methods of animal husbandry and feeding practices permit a quicker animal growth and the production of meat of more desirable quality; better and quicker methods of food technology, including harvesting, refrigeration, preservation, storage and processing will increase the nutritive composition of the foods eaten; the newer knowledge of nutrition or of the food at work in the human body will contribute to the full realization of freedom from want for the number of people in the world today.

Nutrition Now for Health Tomorrow

Optimal nutrition for everybody is not a panacea which will cure the ills of the world. It does, however, offer a starting point from which to build a firm foundation for a just and lasting peace. The primary tool in providing optimal nutrition is food, the ever-present, constant daily

need of humanity. The science of nutrition has explored the intricate nutriment demands of the human body and the potential capacities of the great variety of available foods to provide these requirements in fashioning the body of knowledge which is the basis of nutrition education today. This science is young and growing, being fed by an expanding program of research which is daily enlarging the horizons of our knowledge of foods and nutrition. In applying this information for the welfare of humanity, the nutritionist emphasizes the use of natural foods and decries the blatant appeals to individual aches and pains by vendors of vitamin pills and specific food nutriments.

Food is not a medicine, nor is it to be prescribed on the basis of a chemical formula or equation. The fact that disease or ill health may result from lack of food or improper selection of food (faulty food habits) is no reason to raise false hopes or to cause antipathy towards nutrition, which too frequent use and misuse of the word "diet" connotes in the minds of many people. To the average civilized individual, food is a means of satisfying the appetite, and not just a way of avoiding hunger. Food has an aesthetic value and produces enjoyment and is more than a vitamin or mineral pill, or something that must be consumed just to live.

Since food is such an intimate part of every day life, matters pertaining to diet are usually individual and personal and are the resultant of family, community and national patterns of food habits. In attempting to promote optimal nutrition, the nutritionist is faced with the difficult and complex problem of changing dietary habits which in many instances are reflections of factors having little or no relation to the science of nutrition. As F. LeGros Clark (135) has stated:

> Most of those who lecture or write on nutrition are members of the professional classes (research-workers, doctors and teachers), whereas most of those who receive the message are the families of miners, dockers, railwaymen, farm workers and the like. For food habits the latter have acquired in the process of generations there is always a set of comprehen-

sible causes, among which are not only mistaken or outworn ideas about correct diets, but also such factors as storage space, cooking facilities, income levels, and meal-times.

The child, on the other hand, is not prejudiced by tradition but learns in the home enjoyment or distaste for different foods. Therefore, as was recently pointed out (136): "Since established habits of eating are hard to change, more emphasis should be placed on desirable traits in the early impressionable years. The stress on proper feeding of infants and children over the past several years should soon be paying dividends in better eating habits in the younger generation."

Optimal nutrition practice must be taught the child just as proper methods of hygiene are taught. The outstanding opportunity to teach the proper selection of foods lies in the province of the school lunch program. The possibilities of promoting nutrition by this measure have been presented concisely by Dr. Lydia J. Roberts (137) of the University of Chicago:

Consider for a moment the possibilities for nutritional betterment that lie in this one measure (the school lunch program) if properly carried out. First of all, the requirements that must be met if federal funds are to be secured, provide that the lunch served supply a generous portion of the child's needs for the day, namely:

1. One-half pint of fresh whole milk as a beverage.
2. A protein food as, one of:
    a. two ounces of meat or
    b. one egg or
    c. one-half cup (cooked) of beans or peas or soy beans or
    d. four tablespoons of peanut butter.
3. One cup of vegetables or fruit, or one-half cup of each.
4. One slice or more of bread or muffins or other hot bread made of whole-grain or enriched flour or cereal.
5. Two tablespoons of butter or margarine enriched with vitamin A

These foods may be prepared in many different dishes and menus, but must be included in these amounts.

Can you visualize what it would mean in terms of nutritional benefit if every school child in the country could actually eat that kind of lunch every school day of the year? Can you think what it meant for the ones who were reached this year? In the midwest region alone, which includes Ohio, Indiana, Michigan, Wisconsin, Minnesota, Missouri, Nebraska,

North Dakota and Iowa, 9,355 schools were participating in the program as of May 1944, with an enrollment of 2,732,144 children. In the country as a whole there have been over 4.5 million children participating. We have no statistics to show what the results have been, but the files of the O.D.A. contain many testimonies from sponsors, superintendents, teachers and even children regarding the benefits derived as indicated by the improved growth and health of children, better school attendance, reduced illnesses, and improvement in school work.

I have dwelt on these large-scale measures in some detail, because they can favorably affect nutrition on a wide scale by a simple improvement in a widely consumed food, as iodized salt, enriched bread, fortified margarine, whole or converted rice—or by making available only types of meals that are adequate, as illustrated by the school lunch. One worker in industrial feeding stated recently that, in his opinion, the quickest and most effective way to improve nutrition of industrial workers would be to make available only the foods that it would be desirable for them to eat. Provide only such foods, he said, and they will eat them. Take out coca cola, for example, and the men will drink milk. Schools have been too slow in taking such a stand. They fail to realize that if they provided only the meals that children should have every day and removed entirely all temptation in the way of competing ones, they would by that one simple measure effect enormous benefit. One county superintendent in Kentucky was brave enough to take this step. "If candy doesn't belong in the school lunch room," said he, "take it out." And it was done, just like that over the county! If all schools would have the courage to withstand commercial pressure and allow only such foods and drinks in the lunchroom and on the school premises as they want children to have, they would be taking a long step toward our goal of better nutrition.

Such large scale measures that influence nutrition of people "willy-nilly," are however only part of the program. To realize fully our hopes as outlined, improvement must be effected by the people themselves knowing what good nutrition is and what it means to them in terms of personal health, fitness and vigor, so that they consciously and voluntarily eat regularly the foods that will meet these needs. This end can be accomplished only through an effective program of education among all ages and classes of people.

Educational programs in nutrition of various types are now under way throughout the country. Nutrition classes are being conducted by the American Red Cross, State and Local Nutrition Committees are working in a variety of ways on nutrition education and improvement of people. Commercial groups are broadcasting nutrition information over the radio and in bulletins and advertising material. In fact, the

public is being besieged on every hand by nutrition facts and propaganda. I do not believe there can be any doubt that people know more about nutrition and that there has probably been some real benefit derived from the various types of educational attack. How much is saved will depend on how well the leaders can retain their interest, how well they can consolidate their ground gained, and plan new methods of attack and motivation to preserve and extend the interest roused. One thing that should certainly be done is to preserve the state and local nutrition committees, whether or not the Federal guidance now furnished by the Food and Nutrition Branch of the O.F.D. is continued. In these committees for the first time workers in all different agencies have pooled their efforts in the interest of community nutrition and made great strides in learning to work in cooperation. It would be a backward step to let them die.

If nutrition education is to be effective and our goals realized it must be centered in the public school. This has been said many times, but it needs to be emphasized again. There are many indications that schools are beginning to become more aware of their responsibility. Nutrition workshops for elementary teachers were conducted last summer, and more are under way this year. Teachers are beginning to request courses in nutrition or other types of help, and interest in general is growing. Home Economists should encourage this interest and help in such undertakings.

To sum up, the prospects seem good that some if not all of the nutritional advantages gained during the war period will be continued. The extent this hope is realized will depend to a considerable degree on how well home economists and other leader groups retain their interest and continue and extend their efforts after the period of war-time enthusiasm is past."

Too often nutrition education emphasizes proteins, fats, carbohydrates, minerals and vitamins. These are scientific tools and should be used as such. When properly formulated in terms of foods, they provide for optimal nutrition. In recent years the nutrition of industrial workers has been stressed because of the urgency for the guns, tanks, planes and foods to be ready at the front to enable our armed forces to move forward in their fight for life and democracy.

All that has been said applies equally to people in all walks of life. Adequate food for all is our common goal today. The farmer, the housewife, the lawyer, the teacher, the office worker and the doctor, each must have sufficient

food at the right times, accompanied by suitable environmental factors, if they are to contribute their maximum shares to the welfare of the nation and of the world. Children, the citizens of tomorrow, must be properly fed, if they are to reach maturity as healthy, efficient and constructive men and women. Stronger and healthier bodies are necessary for a greater civilization.

Desire for healthier bodies should not exceed the desire for full enjoyment of one's food and living. Indeed, happiness and enjoyment in living and working are prerequisites to the "good life" and successful living. When the housewife spends so many hours in the day in shopping for the best food, preparing and serving delectable meals, and spending so large a portion of the family budget for food alone, the members of the household are very short-sighted if they do not seek to enjoy to the fullest three square meals per day, composed of the seven basic foods. One can have fun in eating. Children and adults *can adjust* their food habits to satisfy hunger and appetite and at the same time derive full pleasure. Too often, food idiosyncrasies develop through emotional stresses and strains. Healthy minds and bodies are more resistant to such trauma. You do not need to be either a gourmand or epicure to enjoy a well-balanced meal; the intelligent, well adjusted, efficient and successful person capitalizes upon good nutrition and health through foods.

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Vitamin deficienci

	Symptom	Cure P.
A.	Night blindness Skin pimples -	- 86
B -	Beriberi. constipation Heart failure	
	Riboflavin Def.	
	niacin " (Pellagra).	
K -	Hemorrhage	
D -	Rickets	
Ca -	Def	
P.	"	
	Ascorbic Acid Def. - C.	

Date Due